SIX DISCOURSES

DELIVERED BEFORE

THE ROYAL SOCIETY

AT THEIR

ANNIVERSARY MEETINGS,

ON THE

AWARD OF THE ROYAL AND COPLEY MEDALS;

PRECEDED BY

AN ADDRESS TO THE SOCIETY,

ON

THE PROGRESS AND PROSPECTS OF SCIENCE;

BY

SIR HUMPHRY DAVY BART.,

PRESIDENT OF THE ROYAL SOCIETY.

LONDON:

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MDCCCXXVII.

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TO

THE VICE-PRESIDENTS AND COUNCIL

OF

THE ROYAL SOCIETY,

FOR THE YEAR 1827;

AND

TO THOSE FELLOWS WHO FOR SEVEN SUCCESSIVE YEARS HAVE DONE THE AUTHOR THE HONOUR OF PLACING HIM IN THE CHAIR,

THESE DISCOURSES ARE INSCRIBED,

AS A PROOF OF HIS RESPECT AND ATTACHMENT,

AND OF

HIS DEVOTION TO THE INTERESTS

OF

THE ROYAL SOCIETY AND OF SCIENCE.

ADVERTISEMENT.

I have published these Discourses in compliance with the wishes of the Council of the Royal Society. I hope they will be read by the Public in the same spirit in which they were heard by the Fellows. They were intended to communicate general views on the particular subjects of science to which they relate, and not minute information. They must not be considered as finished dissertations;—their principal object was to endeavour to keep alive the spirit of philosophical inquiry and the love of scientific glory.

PARK-STREET, *Jan.* 3, 1827.

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VII.

ADDRESS OF THE PRESIDENT

ON TAKING THE CHAIR OF

THE ROYAL SOCIETY,

FOR THE FIRST TIME;

DECEMBER 7TH, 1820.

ON THE PRESENT STATE OF THAT BODY, AND ON THE PROGRESS AND PROSPECTS OF SCIENCE.

GENTLEMEN,

I HAVE, on a former occasion*, returned you my thanks for the distinguished honour you have done me in electing me your President. I have stated to you my entire devotion to your interests, and to the cause of science. I do not mean to indulge in any further expression of my feelings on this occasion, except to say, that they are deep, and will be permanent.

But I think it my duty, before I enter upon the details of common business, to devote a few words to the present state of the Royal Society, its relations to other scientific bodies, and the prospects and hopes of science.

In the early periods of our establishment, when apparatus was procured with difficulty, when the greatest philosophers were obliged to labour with their own hands to frame their instruments, it was found expedient to keep in the rooms of the Society a collection of all such machines as were likely to be useful in the progress of experimental knowledge: and curators and operators were employed, by whom many capital experiments were made under the eyes of the Society.

* At the Anniversary dinner, November 30.

But since the improvement of the mechanical and chemical arts have afforded great facilities as to the means of carrying on experimental research, the Transactions of the Fellows, recorded by the Society, have, with some few exceptions, been performed in their own laboratories, and at their own expense. It is, however, possible that experiments of great importance, requiring funds which few individuals can command, may be suggested; and it is to be hoped that, on such occasions, the proposers will not fail to recur to the Society. Government, by the command of our august patrons, has always been found ready to assist us, when our inquiries have been connected with objects of national interest; and, on inferior occasions, the aid required might be afforded by an union of the Fellows, many of whom, from their situation in public establishments for teaching and diffusing natural knowledge, have opportunities of procuring the use of grand and expensive apparatus.

When the Royal Society was instituted, it stood alone in Britain; and the associations of learned men that were formed soon after, in different parts of the empire, for pursuing natural science, were either dependent or affiliated societies. But, in these latter times, the field of knowledge has become so extensive, and its objects so various, that separate and independent bodies have arisen for registering observations or collecting facts, each in a different department. It would be impossible that our records, as

they are now published, at our own expense, should contain histories of the multifarious phenomena of all the kingdoms of nature, of all the observations made in zoology, botany, mineralogy, geology, and practical astronomy. It is satisfactory, therefore, to know that institutions exist for preserving and publishing such histories in detail.

I trust that, with these new societies, we shall always preserve the most amicable relations, and that we shall mutually assist each other; and that they, recollecting our grand object, which is, to establish principles on inductive reasoning and experiments, and to make useful applications in science, will, should any discoveries be made by their members respecting general laws, or important facts observed, which seem to lead to purposes of direct utility, do us the honour to communicate them to us. They will have no dishonourable place in being published in those records, which remain monuments of all the country has possessed of profound in experimental research, or ingenious in discovery, or sublime in speculative science, from the time of Hooke and Newton, to that of Maskelyne and Cavendish.

I am sure there is no desire in this body to exert anything like patriarchal authority, in relation to these institutions, or indeed, if there were such a desire, it could not be gratified. But I trust there may exist in the new societies, that feeling of respect and affection for the Royal Society which is due to the eldest brother, to the first-born

of the same family, and that we shall co-operate, in perfect harmony, for one great object, which, from its nature, ought to be a bond of union and of peace, not merely amongst the philosophers of the same country, but even amongst those of different nations.

When, by the unrivalled power of one great genius, and the industry and talent of his illustrious disciples, the laws of the motions of the great masses of matter composing the universe were discovered, and most of the physical phenomena connected with them solved, it appeared as if the field of scientific research were exhausted, as if the rich crops taken from the soil had rendered it steril, and that little was left for the ingenuity and labour of future inquirers; time, however, has proved how unfounded was this opinion, and how nearly approaching to infinite are the objects of natural philosophy. Scarcely has any period of thirty years passed, without offering a train of important discoveries, and every new truth or new fact has led to new researches; becoming, as it were, a centre of light, from which rays have proceeded in different directions, showing to us unexpected objects; so that this kind of knowledge is as inexhaustible as the resources of the human mind; and philosophers, like the early cultivators in a great new continent, by every acquisition they make, discover new and extensive uncultivated spots beyond. As a chart of what is known in lately-discovered regions is essential in guiding the traveller

to new researches, so, in natural knowledge, notices of the limits or boundary lines of different new departments of science, and of the aspects and characters of novel objects may be useful to scientific investigators; I shall, therefore, offer a few hints respecting those different departments of inquiry which appear most capable of improvement.

In pure Mathematics: though their nature, as a work of intellectual combination, framed by the highest efforts of human intelligence, renders them incapable of receiving aids from observations of external phenomena, or the invention of new instruments, yet they are, at this moment, abundant in the promise of new applications; and many of the departments of philosophical inquiry which appeared formerly to bear no relation to quantity, weight, figure, or number, as I shall more particularly mention hereafter, are now brought under the dominion of that sublime science, which is, as it were, the animating principle of all the other sciences.

When the boundary of the solar system was enlarged by the discovery of the Georgium Sidus, and the remote parts of space accurately examined by more powerful instruments than had ever before been constructed, there seemed little probability that new bodies should be discovered nearer to our earth than Jupiter; yet this supposition, like most others in which our limited conceptions are applied to nature, has been found erroneous. The discoveries of Piazzi,

and those astronomers who have followed him, by proving the existence of Ceres, Pallas, Vesta, and Juno—bodies smaller than satellites, but in their motions similar to primary planets—have opened to us new views of the arrangement of the solar system. Astronomy is the most ancient, and the nearest approaching to perfection of the sciences; yet, relating to the immensity of the universe, how unbounded are the objects of inquiry it presents! And, amongst them, how many grand and abstruse subjects of investigation! Such, for instance, as the nature of the systems of the fixed stars and their changes, the relations of cometary bodies to the sun, and the motions of those meteors which, in passing through our atmosphere, throw down showers of stones; for it cannot be doubted that they belong to the heavens, and that they are not fortuitous or atmospheric formations; and, in a system which is all harmony, they must be governed by fixed laws, and intended for definite purposes.

The grand question of universal gravitation, and its connexion with the figure of the earth, has been long solved; but the mechanical refinements of one of our Fellows, have afforded means of estimating, with more perfect exactness, the force of gravity: and that pendulum, which is so well fitted as a standard of measure, may be admirably applied in acquainting us with the physical constitution of the surface of the earth. I trust we shall have some interesting new

experiments on the subject. Our brethren of the Royal Academy of Sciences of Paris, who have laboured with so much zeal and activity towards the measurement of a great arc of the meridian in France and Spain, are, I know, extremely desirous their measures may be connected with those carried on by the command of the Board of Ordnance in Britain,—That the work may be completed by the philosophers of both countries. Should this be done, there will be established, on the highest authority, an admeasurement of nearly 20 degrees, or $\frac{1}{18}$th of the whole circumference of the earth, from the Shetland Islands to Formentera, which will be a great record for posterity, and an honour for our own times.

I cannot pass over the subject of the figure of the earth without referring to the late voyage to the Arctic Regions, which has shown that there is an accessible sea to the west of Baffin's Bay, presenting hopes of other discoveries, and which, though unsuccessful in its immediate objects, has terminated, nevertheless, in a way equally honourable to those by whom the expedition was planned, and to the brave, enterprising, and scientific navigators by whom it was executed. Such expeditions are worthy of the great maritime nation of the world, showing that her resources are not merely employed for gaining power or empire, but likewise for what men of science must consider as nobler purposes, the attempting discoveries which have the common benefit

of mankind for their object, and the extension of the boundaries of science.

In the theory of light and vision, the researches of Huyghens, Newton, and Wollaston, have been followed by those of Malus; and the phenomena of polarization, which we owe to the genius of that excellent and much to be lamented philosopher, are constantly leading to new discoveries; and, notwithstanding the important labours of Arago, Biot, Brewster, and Herschel, the inquiry is not yet exhausted; and it is extremely probable, that these beautiful results will lead to a more profound knowledge than has hitherto been obtained, concerning the intimate constitution of bodies, and establish a near connexion between mechanical and chemical philosophy.

The subject of heat, so nearly allied to that of light, has lately afforded a rich harvest of discovery; yet it is fertile in unexplored phenomena. The question of the materiality of heat will probably be solved at the same time as that of the undulatory hypothesis of light, if, indeed, the human mind should ever be capable of understanding the causes of these mysterious phenomena. The applications of the doctrine of heat to the atomic or corpuscular philosophy of chemistry, abound in new views, and probably, at no very distant period, these views will assume a precise mathematical form. There are many remarkable circumstances which seem to point to some general law on the subject:—first, the appa-

rent equable motion of radiant matter, as light and heat, through space; second, the equable expansion of all elastic fluids, by equal increments of temperature; third, the contraction or expansion of gases, by chemical changes, in some direct ratio to their original volume, for instance $\frac{1}{4}$ or $\frac{1}{3}$; fourth, the circumstance that the elementary particles of all bodies, appear to possess the same quantity of heat.

In electricity, the wonderful instrument of Volta, has done more for the obscure parts of physics and chemistry, than the microscope ever effected for natural history, or even the telescope for astronomy. After presenting to us the most extraordinary and unexpected results in chemical analysis, it is now throwing a new light upon magnetism,

Suppeditatque novo confestim lumine lumen.

But upon this question I shall enter no further, as it has been discussed, in the discourse given on the award of the Copleian medal to M. Oersted, by my predecessor in office, with all his peculiar sagacity and happy talent of illustration.

To point out all the objects worthy of inquiry in chemistry, would occupy the time appropriated to many sittings of the Society. I cannot, however, avoid mentioning, amongst important desiderata, the knowledge of the nature of the combinations of that principle existing in fluor, or Derbyshire spar, and which has not yet been obtained pure; the relations of that extraordinary fact, the metallization

of ammonia, and the connexion between mechanical and chemical phenomena, in the action of voltaic electricity. I must congratulate the Society on the rapid advances made in the theory of definite proportions, since it was advanced in a distinct form, by the ingenuity of Mr. Dalton. I congratulate the Society on its progress, and on the promise it affords of solving the recondite changes, owing to motions of the particles of matter by laws depending upon their weight, number, and figure, and which will be probably found as simple in their origin, and as harmonious in their relations, as those which direct the motions of the heavenly bodies, and produce the beauty and order of the celestial systems.

The crystallizations, or regular forms of inorganic matter, are intimately connected with definite proportions, and depend upon the nature of the combinations of the elementary particles; and both the laws of electrical polarity, and the polarization of light, seem related to these phenomena. As to the origin of the primary arrangement of the crystalline matter of the globe, various hypotheses have been applied, and the question is still agitated, and is perhaps above the present state of our knowledge; but there are two principal facts which present analogies on the subject, one, that the form of the earth is that which would result, supposing it to have been originally fluid; and the other, that in lavas, masses decidedly of igneous origin, crys-

talline substances, similar to those belonging to the primary rocks, are found in abundance.

In following the sensible phenomena of nature, from the motions of the great masses of the heavenly bodies which first impress the senses and affect the imagination, to the changes individually imperceptible, which produce the results of crystallization, there is a regular gradation, and a series conformable to analogy; and where crystallization ends, another series, that of animated nature, begins, governed by a distinct set of laws, but obedient to a principle, the properties of which, independent of matter, can never be submitted to human observation. The functions and operations of organized beings, however, offer an infinite variety of beautiful and important objects of investigation. For instance, in those refined chemical processes, by which the death and decay of one species afford nourishment to another and higher order, by which the water and inert matter of the soil and the atmosphere are converted into delicately-organized structures, filled with life and beauty. In vegetable physiology, how many phenomena still remain for investigation! the motion of the sap, the functions of the leaves, for instance, and the nature of the organs of assimilation. In animal physiology, the subjects are still more varied, more obscure, and of a higher character. May we not hope those philosophers of the schools of Grew and Hunter, who have already done so much for us, will not

cease their efforts for the improvement of these branches of science, which are not merely important in their philosophical relations, but of great utility, the one to agriculture, the other to medicine?

Gentlemen, to conclude, I trust in all our researches we shall be guided by that spirit of philosophy, awakened by our great masters, Bacon and Newton; that sober and cautious method of inductive reasoning which is the germ of truth and of permanency in all the sciences. I trust that those amongst us who are so fortunate as to kindle the light of new discoveries, will use them, not for the purpose of dazzling the organs of our intellectual vision, but rather to enlighten us, by showing objects in their true forms and colours; that our philosophers will attach no importance to hypotheses, except as leading to the research after facts, so as to be able to discard or adopt them at pleasure, treating them rather as parts of the scaffolding of the building of science, than as belonging either to its foundations, materials, or ornaments; that they will look, where it be possible, to practical applications in science, not, however, forgetting the dignity of their pursuit, the noblest end of which is, to exalt the powers of the human mind, and to increase the sphere of intellectual enjoyment, by enlarging our views of nature, and of the power, wisdom, and goodness of the Author of nature.

Gentlemen, the Society has a right to expect from those

amongst its Fellows, gifted with adequate talents, who have not yet laboured for science, some proofs of their zeal in promoting its progress; and it will always consider the success of those who have already been contributors to our volumes, as a pledge of future labours.

For myself, I can only say, that I shall be most happy to give in any way assistance, either by advice or experiments, in promoting the progress of discovery. And though your good opinion has, as it were, honoured me with a rank similar to that of general, I shall be always happy to act as a private soldier in the ranks of science.

Let us then labour together, and steadily endeavour to gain what are perhaps the noblest objects of ambition—acquisitions which may be useful to our fellow-creatures. Let it not be said, that, at a period when our empire was at its highest pitch of greatness, the sciences began to decline; let us rather hope that posterity will find, in the Philosophical Transactions of our days, proofs that we were not unworthy of the times in which we lived.

DISCOURSE OF THE PRESIDENT,

NOVEMBER 30TH, 1821,

IN ANNOUNCING THE AWARD OF TWO MEDALS, ON SIR GODFREY COPLEY'S DONATION.

ONE TO

J. F. W. HERSCHEL, Esq., F.R.S.,

FOR HIS VARIOUS PAPERS ON MATHEMATICAL AND PHYSICO-MATHEMATICAL SUBJECTS, PUBLISHED IN THE PHILOSOPHICAL TRANSACTIONS.

AND THE OTHER TO

CAPTAIN EDWARD SABINE, R.A.

FOR HIS PAPERS CONTAINING AN ACCOUNT OF HIS VARIOUS EXPERIMENTS AND OBSERVATIONS, MADE DURING THE VOYAGE AND EXPEDITION IN THE ARCTIC REGIONS.

GENTLEMEN,

THE progress of discovery, even when belonging to past times or to distant countries, is always an agreeable subject of contemplation to philosophical men; but the pleasure derived from it is much higher when it arises from the exertions of the talents of our own countrymen, when it originates in our own body, and when there is the power, not only of acknowledging and rejoicing at it, but likewise of distinguishing the persons to whom it is owing by a permanent mark of respect. You will therefore, I am sure, Gentlemen, have as much satisfaction in hearing as I have in stating, the decision of the council of the Royal Society, in the award of two of your Copley medals,—one of this year, and one not disposed of on a former occasion,—to two of our worthy Fellows, whose papers have been published in the *Philosophical Transactions*, and whose merits have been for some time known to you,—John Frederick William Herschel, Esquire, and Captain Edward Sabine, of the Royal Artillery. I shall ask your attention for a short time, Gentlemen, whilst

I state the grounds of the decision of your Council, and I shall begin with the labours of Mr. Herschel.

There is certainly no branch of science so calculated to awaken our admiration as the sublime or transcendental geometry, not only as showing the wonderful powers and researches of the human mind, but likewise demonstrating the wisdom and beauty of the laws of the system of the universe. It is, perhaps, the highest triumph of human intelligence, that, proceeding from the consideration of mere unities or points, lines, or surfaces, it should, by gradual generalizations, substitutions, and abstractions, be able to arrive, not only at the knowledge of all possible conditions of number and quantity, but likewise of time and motion; and by employing its own pure intellectual creations, to anticipate the results of observation and experiment, and determine the movements, not only of the bodies which form permanent parts of our system, but likewise of those which seem only occasionally to visit it, and which belong, as it were, to the immensity of space.

Whether the importance of the subject be considered, or the glory that has been derived by the society from the labours of those amongst its members who have cultivated the higher branches of the mathematics, it must be very gratifying to you to hear that Mr. Herschel, after gaining, at a very early period of life, academical honours of the highest kind in that university where the exact sciences are

most profoundly studied, has successfully continued his pursuit of this kind of knowledge; and not contented with understanding and illustrating the most elaborate works of his predecessors and contemporaries, has made additions to them, and that even in the most abstruse and difficult branches of analysis.

Four papers of Mr. Herschel, on pure mathematical subjects, are to be found in your *Transactions*. The first, on a remarkable application of Cotes's theorem. The second, on the consideration of various parts of analysis, in which he has examined one of the most sublime points of the doctrine of fluxions, the calculus of generating functions, and makes a new application of them to the case of logarithmic transcendents, and derives from them the summation of one of the most important series which has ever received discussion. The third paper is on the developement of exponential functions, together with several new theorems relating to finite differences. The fourth paper is on circulating functions, and the integration of a class of finite differences into which they enter as co-efficients.

I cannot attempt an analysis of these papers; that their merits may be understood, they must be deeply studied; and, by the best mathematicians, they are regarded as ingenious and profound.

The author, in treating of algebraical or fluxional instruments, as they may be called, of the relations of variable

quantities or functions which may be supposed capable of indefinite diminution or increase, has indulged in no vague metaphysical abstractions. He has shown a great love of simplicity in his processes, appearing rather desirous of being intelligible and useful, than anxious to display the variety and extent of his acquisitions. In all these papers Mr. Herschel has proved himself intimately acquainted with the works of the great masters of analysis, and has exhibited equal powers of seizing particular applications of methods already known, and of developing new and general views; thus demonstrating himself the worthy associate of a Brinkley, a Woodhouse, an Ivory, and a Young, who have, in late times, travelled, with so much zeal and success, towards mathematical discoveries, in these noble paths of investigation opened by the unrivalled genius of Newton, and too long deserted by our countrymen, and occupied, almost exclusively, by illustrious foreigners.

But Mr. Herschel has not limited himself to the invention or developement of formulæ, to what may be called the construction of the instruments of the science of quantity, he has made important applications of them, which is perhaps the highest claim that can be made to the approbation of this Society; for though, as a mere exercise, the higher mathematics strengthen the reasoning faculties, and afford intellectual pleasure, yet it is by enabling us to solve the physical phenomena of the universe, and modify the properties

of matter, that they have their grandest end and use. In these respects, they are really power; and they may be compared to that power which we witness in the vapour of water, which, passing into the free atmosphere, exhibits only a pleasing spectacle; but which applied in the steam-engine, becomes the moving principle of the most useful and extensive machinery, and the source of the most important arts of life.

There are two papers of Mr. Herschel's, in the last volume of the *Transactions*, on physico-mathematical subjects, and both of them connected with optical phenomena. All the Fellows must be acquainted with the beautiful discoveries of Malus, of that peculiar modification given to rays or particles of light by their passage through certain transparent bodies, or by their reflection from certain surfaces, which has been called polarization; and the ingenious and elaborate researches of Biot, Arago, and Brewster, in consequence of the discovery, have been illustrated from this chair by your venerable and illustrious deceased President. But, notwithstanding the talents and industry of these distinguished philosophers, Mr. Herschel has been able to add to the subject some novel investigations; and, in reasoning upon the tints developed by polarized light, has reduced the explanation of the phenomena to one general fact, namely, that the axes of double refraction differ in their position in

the same crystal, for the different coloured rays of the spectrum, and that this element must enter into all rigorous formulæ of double refraction; and, consequently, that the idea of the colours of thin plates being correspondent with the tints developed by polarized light, is not conformable to the facts.

Though it appears that some similar observations were made by one of the philosophers just mentioned, without the knowledge of what Mr. Herschel had done, yet the latter has unquestionably the priority: and it is agreeable to find a harmonious coincidence between two accurate reasoners and acute observers.

In this paper Mr. Herschel has extended or modified the discoveries of others; the second is more original, and on a subject highly important in practical optics.

With the view of enabling artists to substitute, in working their glasses, certain mathematical rules for empirical methods, Mr. Herschel has presented, under a general and uniform analysis, the whole theory of the aberration of spherical surfaces, and has furnished simple tabular rules, by which the workmen may adapt their tools to the object required, in forming glasses for the telescope—thus adding to the immense obligations owing to the name of Herschel, in every thing connected with the progress of modern astronomy and the knowledge of celestial phenomena.

Convinced, Gentlemen, that you approve of the decision of your Council, I shall present this medal, engraved with his name and the date of the year, to Mr. Herschel.

Mr. Herschel,

Receive this medal, Sir, as a mark of our respect and of our admiration of those talents which you have applied with so much zeal and success, and preserve it as a pledge of future exertions in the cause of science and of the Royal Society; and, believe me, you can communicate your labours to no public body by whom they will be better received, or through whose records they will be better known to the philosophical world. You are in the prime of life, in the beginning of your career, and you have powers and acquirements capable of illustrating and extending every branch of physical inquiry; and, in the field of science, how many are the spots not yet cultivated! Where the laws of sensible become connected with those of insensible motions, the mechanical with the chemical phenomena, how little is known! In electricity, magnetism, in the relations of crystallized forms to the weights of the elements of bodies, what a number of curious and important objects of research! And they are objects which you are peculiarly qualified to pursue and illustrate.

May you continue to devote yourself to philosophical

pursuits, and to exalt your reputation, already so high —

"Virtutem extendere factis."

And these pursuits you will find not only glorious but dignified, useful and gratifying in every period of life: this, indeed, you must know best in the example of your illustrious father, who, full of years and of honours, must view your exertions with infinite pleasure; and who, in the hopes that his own imperishable name will be permanently connected with yours in the annals of philosophy, must look forward to a double immortality.

I shall now speak of the researches of Captain Sabine.

You will, Gentlemen, I am sure, anticipate the grounds of the decision of your council, in awarding to him the other medal.

The Expeditions to the Arctic Regions, which have been planned with so much liberality of view by the Admiralty, and which are carrying on with so much skill, perseverance, and courage, by the brave officers and seamen concerned in them, have awakened so strong an interest in the public mind, and are so well known in the printed details, that it is almost unnecessary to point out the particular merits of the most distinguished amongst those bold and enterprising persons, who have thus devoted themselves to the cause of science and their country. Yet, Captain Sabine having been appointed,

in consequence of the recommendation of the council of the Royal Society, astronomer and philosophical observer to the two first of the expeditions, and having more than answered their recommendation, they have thought it right to express their sense of his high merits by the vote I am now announcing.

Captain Sabine had been for some time known as an active officer, and by his labours in these expeditions, he has proved himself worthy the name of an accurate philosophical observer: he has shown great industry and perseverance in making his experiments, under circumstances when they were peculiarly difficult, and has accumulated an immense number of observations in astronomy and meteorology, and on the phenomena of magnetism and gravitation.

Active courage, Gentlemen, is a quality so inherent in every Briton, and so nobly displayed in our naval and military triumphs, that it is scarcely necessary to praise it; but, there is a fortitude and a patience in enduring hardships, and in bearing privations, which may be considered as rarer qualities, and which demand our highest commendation. The place, as you know, where Captain Sabine conducted his principal experiments was on the ice of the Polar Sea, where the vessel was for several months frozen up. During a considerable portion of the time, he was in darkness, or only guided by a very doubtful twilight; and such was the intensity of the cold, that exposure, even in the warmest

clothing, to the atmosphere for any time, was always painful, and sometimes dangerous. It was impossible to touch the metallic instruments with the naked hand, without being frost-bitten; and such was the temperature of this inclement spot, probably as cold as any belonging to the northern hemisphere, that the artificial horizon of mercury became frozen during an observation; yet Captain Sabine's experiments seem to have been conducted with as much care and precision, as if he had been possessed of the conveniences and luxuries of a royal observatory, and the advantages and repose of the happiest climate and situation.

Three of his papers have been published in your *Transactions:* the two first contain observations relating to magnetic phenomena, such as, the influence of the iron in the ship, upon the correctness of results obtained by the compass, and the intensity and variation of the magnetic force in approaching the magnetic pole, which last are given in a series of tables. The other paper is more important, containing an account of experiments on the vibrations of the pendulum, in different latitudes.

On the subject of this paper, I shall enter into a few details. The invention of the pendulum, by Galilæo Galilæi, is placed beyond all doubt; and that this illustrious philosopher endeavoured to apply it as a measure of time, and that his son, Vincenzo Galilæi constructed the first pendulum clock at Venice, in 1649, is proved, both by manuscript

documents that I have seen at Florence, and by the printed testimonies of the Academia del Cimento; but the great principle of the instrument, in its application to clock-work, it is well known, is owing to the illustrious Huyghens, who discovered that the vibrations were isochronous, when performed in cycloidal arcs.

It is not certain by whom the pendulum was first proposed as an universal standard of measure, but it is hardly likely that such an application of it should have escaped the sagacity of the Dutch philosopher; yet, as early as 1661, Lord Brouncker, after mathematically demonstrating the properties of the pendulum, by a very elaborate analysis, brought in a paper to the Royal Society on a common measure, and Sir William Petty, at the same meeting, proposed to make experiments, for this purpose, on the vibrations of the pendulum, and Sir Christopher, then Doctor, Wren, was desired to think of some other common measure, and he proposed, on his return from Oxford, a certain part of the length of a degree upon the earth. Various experiments, likewise, seem to have been made by different members of the Royal Society, between 1661 and 1664, on the times of the vibrations of pendulums of different lengths, as standards of measure; and Huyghens did not propose the pendulum vibrating seconds, as an universal standard, till the end of this year, November, 1664; and that, in a letter to the Royal Society,

but the proposition is given in a very precise and beautiful form.

When the calculations of Newton and Huyghens, and the experiments of Richer, had proved that the vibrations of the same pendulum were not performed in the same times in different latitudes, M. de la Condamine proposed, and endeavoured to establish, the length of the pendulum vibrating seconds at the equator, as a common standard. But in no part of Europe was this standard adopted; and the French metre, as you well know, is founded upon the measure by triangulation, made by some distinguished members of the Institute, of a small arc of the meridian.

It is to the scientific zeal and enlightened views of our worthy treasurer, Mr. Gilbert, that the elaborate investigation of the properties of a pendulum, as an universal standard of measure, is owing. By making it a question of national importance in parliament, he directed all the scientific talents and resources of the country to the object; and the invariable pendulum, contrived with such a happy spirit of invention, and examined with such unceasing activity and minute accuracy by Captain Kater, was the fortunate result.

The experiments made with this beautiful instrument, by the inventor, are well known to you, having been published at full length in your *Transactions*. Captain Kater's results proved that it was a most delicate measure of gravity, not

only for the whole earth, but likewise as even marking the density of particular parts of the surface; and his conclusions rendered it very desirable, that the length of the pendulum, or, what is tantamount, the number of its vibrations, should be determined as extensively as possible, from the Polar to the Equatorial Regions.

A happy opportunity occurred, with respect to the Arctic Pole, in the two late expeditions; and Captain Sabine, being provided with the necessary means, applied them with all possible accuracy and industry, as the details of his paper prove; and in north latitude of nearly 74½ degrees, the extreme point of his observations, he has shown the length of the pendulum vibrating seconds, to be 39.207 inches, and the mean of his experiments gives the compression of the earth, at the Pole, as $\frac{1}{311}$.

Captain Sabine did not accompany the third expedition, because he conceived that he had effected all that he was capable of performing with the pendulum in north latitudes, which was the great object of his researches in the two former voyages; and his scientific ardour made him resolve to endeavour to complete his investigation even to the Line; and it is in consequence of his carrying this resolution into effect, that he is not now present to witness the strong interest you have taken in his pursuits. Having braved the long night and almost perpetual winter of the Polar Regions,

he is gone, with the same laudable object, to expose himself to the burning sun and constant summer of the Equator.

Should Providence bestow on him health and a successful voyage, I have no doubt he will return to us with a valuable collection of facts and observations. He has carried with him instruments of various kinds for making researches,—as to the temperature and currents of the ocean,—the effects of heat and light,—the state of the atmosphere,—and other objects connected with the natural history of the globe And his researches on the pendulum, combined with those Captain Kater has made in our own island, and others carrying on at the observatory established at the Cape of Good Hope, and by Sir Thomas Brisbane in New South Wales, will, I have no doubt, furnish a mass of information, from which the figure of the earth may be deduced with much more accuracy, than from any preceding experiments or deductions. And as the Royal Society, through its most illustrious member, had the honour of publishing to Europe, more than a century ago, the grand theoretical principles of this discovery, may we not hope that its present Fellows will give it all the practical elucidations of which it is susceptible?

Captain Sabine not being present, Gentlemen, for the reasons I have stated, I shall deliver the medal to his friend and brother.

Mr. Sabine,

In informing Captain Sabine of what has taken place this day, you will, I trust, state to him our deep sense of his merits. His knowledge of this expression of our opinion may, perhaps, animate him during the difficult enterprise he has undertaken; for he has already shown how highly he values the praise of the Royal Society, which, with the good opinion of his countrymen, has been hitherto the only reward of his labours. Assure him how strongly we feel his disinterestedness and genuine love of science, and that our constant wishes are expressed for his safe return, and for the successful accomplishment of all the objects of his voyage, which will ensure, even to him, additional claims upon the gratitude of all lovers of science.

DISCOURSE OF THE PRESIDENT,

ANNIVERSARY, NOVEMBER 30TH, 1822,

ON THE CHARACTERS OF SOME DECEASED FELLOWS;

SIR HENRY C. ENGLEFIELD, BART., SIR WILLIAM HERSCHEL, DR. MARCET,
THE REV. SAMUEL VINCE, DR. PARRY, DR. CARMICHAEL SMITH,
MM. HAUY, DELAMBRE, AND BERTHOLLET.

AND ON THE

AWARD OF THE MEDAL ON SIR GODFREY COPLEY'S DONATION,

TO

THE REV. PROFESSOR BUCKLAND,

FOR HIS PAPER ON THE BONES OF HYÆNAS, AND OTHER ANIMALS,
FOUND IN A CAVE AT KIRKDALE, IN YORKSHIRE.

WITH GENERAL VIEWS ON THE PROGRESS AND PROSPECTS
OF GEOLOGY.

In perusing this list (of deaths), Gentlemen, some names have arrested my attention, with respect to which, I consider it as a duty to say a few words. I cannot enter upon a studied eulogy of the illustrious dead; but I am sure you will not consider a short tribute of respect to their memory, such as naturally arises out of this occasion, improper, or out of place; and which, however unequal it may be to their merits, will, I trust, be in unison with the feelings of the Society.

Sir Henry Englefield, the first person whom I shall mention, was known to you as an accomplished gentleman, gifted with a great variety of knowledge, which he was always ready to communicate. He had followed astronomy much as an amusement, and sometimes as a study; and his early work on Comets displays considerable research, and a minute acquaintance with his subject. Though his scientific acquisitions were very general, they were, nevertheless, accurate; and he has produced good papers on several different subjects of experimental research. He was a clear writer,

and a learned antiquarian, a liberal collector, and a judge of works of art. In conversation he was ready and fluent, amiable and discursive; and he will long be regretted as an entertaining companion, a warm and excellent friend, a truly honest man, and an ornament to the class of society in which he moved.

On the labours and discoveries of Sir WILLIAM HERSCHEL, it is unnecessary to dwell; they have so much contributed to the progress of modern astronomy, that his name will probably live as long as the inhabitants of this earth are permitted to view the solar system, or to understand the laws of its motions. The world of science—the civilized world, are alike indebted to him who enlarges the boundaries of human knowledge, who increases the scope of intellectual enjoyment, and exhibits the human mind in possession of new and unknown powers, by which it gains, as it were, new dominions in space; acquisitions which are imperishable; not like the boundaries of terrestrial states and kingdoms, or even the great monuments of art, which, however extensive or splendid, must decay; but secured by the grandest forms and objects of nature, and registered amongst her laws.

The acuteness and accuracy of Sir William Herschel, as an astronomical observer, are demonstrated by his discovery of a new planetary system, and of a number of satellites

before unknown. His genius for speculation, and his powers of inductive reasoning, are illustrated by his views of the stars and nebulæ, composing what we know of the system of the universe; and his talents for physical research are shown by his important discovery of invisible rays in the solar spectrum.

The moral qualities of this celebrated man are so well known, that I shall barely touch upon them. Raised entirely by his own merits, and by the powers of his own intellect, to the station he occupied in the world of science, honoured by the patronage and kindness of a most beneficent sovereign, he was spoiled neither by glory nor by fortune, and always retained the native simplicity of his mind. In all his domestic and social relations, he was most amiable. As his life had been useful and honourable, so was his death happy: and he had little left to wish for, except that expansion of intellect which can only belong to the mind in a higher state of existence. Every year of his life was distinguished by some acquisition or blessing; and when age no longer permitted him to make discoveries he saw his son taking his place, and distinguishing himself in the same career.

If the scientific world in general have cause to regret the loss of Sir William Herschel, and to reverence his memory, the Royal Society, in particular, has a deeper sense of sorrow, and a higher motive for veneration. All his important

papers were published in your *Transactions;* and no name in modern times has more contributed to your glory.

Sir William Herschel died at the advanced age of eighty-three; Sir Henry Englefield was seventy; but Doctor MARCET, another of your worthy deceased Fellows, had not much passed fifty years; and his death was most unexpected and deeply to be lamented. He was but a short time before apparently in excellent health and spirits, and active in body and mind. Circumstances of a happy kind likewise enabled him to devote himself entirely to science; and his different papers, published in the *Transactions*, on chemical subjects, show how capable he was of sound reasoning, accurate experiments, and ingenious views, in this department of science; and, I doubt not, had his life been spared, it would have been devoted to laudable scientific objects. A more amiable man than Dr. Marcet, I believe, never lived. There was a simple dignity in his character which commanded respect; and a warmth of manner, arising from a warmth of heart, which ensured affection. But why should I dwell upon moral and social qualities, which all those who knew him must feel, and which I can never describe with sufficient truth to give an idea of, to those who did not know him?

The Reverend SAMUEL VINCE, Plumian Professor of Astronomy and Experimental Philosophy, in the University of

Cambridge, was, like Sir William Herschel, a man who rose to distinction entirely by the exertion of his own talents. He was well known to you as a profound mathematician, and a clear elementary writer. It is enough to say of him, that he was distinguished in the great mathematical school of this country, and that we are now profiting by the labours and profound acquisitions of his scholars.

I shall mention Dr. PARRY only as an enlightened and ingenious physician, and an amiable and accomplished man; and Dr. CARMICHAEL SMITH, as having received a parliamentary reward for the application of nitrous acid vapour in destroying contagious matter.

On our Foreign list, the first name that occurs is the Abbé HAUY, who was known as a good natural philosopher, and whose reputation will pass down to posterity on account of his work on Crystallography, in which he has endeavoured to make the crystalline form of mineral bodies, the important character of their classification; and who, in his application of this principle, assisted by chemistry, either produced or prepared the way for some remarkable discoveries.

The next is M. DELAMBRE, Secretary to the Royal Academy of Sciences at Paris; an excellent astronomer, whose work on the History of Astronomy is a model of this kind

of composition; he was distinguished by many accurate labours in his favourite science: but his greatest experimental work was that which he made in conjunction with Mechain, the measurement of an arc of the meridian in France. He was a good classical scholar, an elegant and impartial writer; and his Discourses to the Institute, on the annual progress of science, are marked by good taste, candour, a love of justice, and a truly philosophical spirit.

Bertholle t might be considered the patriarch of modern chemistry—the friend and companion of Lavoisier, and Guyton de Morveau. He had contributed much to the establishment of that view of the combinations of oxygen, which has been called the anti-phlogistic system; and took a part in framing the new nomenclature. His principal discovery was that of the composition of ammonia, but he was the author of many excellent papers on chemical subjects; and the most celebrated French chemists now alive were his pupils. He was an excellent logician and a good experimenter; and remarkable for a high degree of candour, renouncing his opinions, with the greatest readiness, whenever the progress of science was opposed to them; and this even in old age. He was amiable and unaffected, and the liberal patron of rising genius wherever it appeared; and made a point, even in the bosom of the Academy of Sciences, of doing justice to foreigners.

Copley Medal.

The duty I have now to perform, I consider as the most gratifying belonging to the office of your President. It is to announce to you, Gentlemen, the decision of your council, in awarding the medal of the Society, for the year 1822, on Sir Godfrey Copley's donation, to the Reverend William Buckland, your worthy Fellow, and professor of geology in the University of Oxford, for his account of the fossil teeth and bones, discovered in a cave near Kirkdale, in Yorkshire, and published in the *Philosophical Transactions* for the present year.

This is the first time that a communication on a subject of pure geology has been honoured with so distinguished a mark of approbation; and from the merits of the communication, which has been for some time before the public, I am convinced you will think your council has performed an act of justice, and not of favour, towards the author.

It is not a little remarkable, that whilst the natural history of the heavenly bodies, so far removed from us, was the earliest object of scientific research, the mineral philosophy of the earth we inhabit, of the substances under our feet, has been the latest. The brilliancy of the celestial phenomena, their connexion with the seasons, and with the superstitions of the ancients; the facility with which mathematics were

applied to their figures and motions, and their relations to time, rendered astronomy, in all ages and countries, a popular study; whereas the difficulty of penetrating into the strata of the surface of the globe, the apparent disorder and confusion of their contents, and the want of any scientific principles applicable to the subject, for a long while prevented geology from being numbered even among the sciences.

By the ancients, cosmogonies or dreams respecting the origin and changes of our planets, were substituted for actual observation; and though, in the early progress of general philosophical inquiries in Europe, particularly amongst the works of early Members of this Society, or contributors to the *Transactions*, such as Hooke, Lister, Holloway, Pococke, and Strachey, some general views were formed, and accurate histories of particular phenomena recorded; yet it is only within the last half century that the subject has been pursued, in the active spirit of research, by truly philosophical minds; and that it has been an object of general scientific attention.

At the beginning of this period, mineralogy offered a regular arrangement of fossil substances; and De Saussure, Pallas, and, above all, Werner, considering and perfecting it as the alphabet of geology, endeavoured to read, slowly and carefully, this interesting part of the Book of Nature. Chemistry, annually making a rapid progress, had not only explained the intimate nature of mineral bodies, and so

afforded correct means of classing them, but likewise offered the powers of judging of their past changes, by analyses deduced from accurate experiments; and the comparative anatomy of plants and animals, in tracing and fixing the resemblances between existing beings, had furnished the links of inductive reasoning, by which the extinct species belonging to the mineral kingdom were to be examined and known.

Under such advantages it was to be expected that a rapid advance would be made in the science. Private and public museums have been formed in every part of Europe. Societies have been instituted for the express purpose of pursuing geological inquiry. Maps, in which the mineral history of districts and countries is laid down, have been published; and within the last twenty years, it is not perhaps unjust to say, that rational geology has made more progress than in all the preceding time.

In a discourse so limited in its object as that I am now delivering, it would be impossible to mention, even in the most cursory manner, the labours of those inquirers who have been most successful in this field of science; but no one amongst them has been more distinguished, by ardour in the pursuit of knowledge, by success in geological discovery, and soundness in philosophical reasoning, than Mr. Buckland. His lectures, in the University of Oxford, have raised a numerous class of disciples, who are following his

praiseworthy example in the pursuit of science; and his former publications equally proved his indefatigable spirit of research, his accuracy of observation, and his caution and sagacity in drawing conclusions.

Upon the nature of the paper which your council has considered as entitling him to the medal, I shall make a few observations. It has been probably read with interest by every one who is here present; I will not, therefore, attempt to analyse the details. I shall merely point out the particular fact that it establishes in the history of the globe, and which I consider as of great importance; but for this purpose it will be necessary to offer a few preliminary observations on the structure of the known part of our globe, and of the changes which it has undergone.

It has been ascertained, by the examination of a great extent of the surface, that the rocks which rise to the greatest elevation in the atmosphere, and those found at the lowest depths to which human industry has, as yet, penetrated, are composed wholly of crystalline matter, containing no remains of organized beings, or of any former order of things: upon these rocks, at common heights or depths, are found others, principally constituted of crystalline matter, and affording some few remains of shells, fishes, and plants. To these succeed a number of strata, or layers, less consolidated, affording much smaller proportions of crystals, abounding in fragments of the older rocks, and containing imbedded in

them, the remains of plants, shells, fishes, oviparous reptiles, amphibia, and birds; each stratum being characterized by the peculiarity of its organized remains.

Upon these consolidated and extensive strata are found others, which, when not produced by deposition of gypsum, in what may be called fresh-water formations, consist of clay, sand, gravel, or water-worn stones, and in these are discovered, amongst a vast number of other deposites, the remains of viviparous quadrupeds.

In the lowest strata, it has been observed, and I have found by experiments, these organized remains contain none of their original bony matter; but, in proportion as the formations or depositions may be supposed to be more recent, so in proportion is more of the original matter of the bone or shell found in them. The remains of the bones of the animals of the saurus or lizard kind, found in the limestone of Sussex or Dorsetshire, contain very little animal matter, but much phosphate of lime; those in the Kirkdale cave contain almost all their phosphate of lime, but have lost a considerable portion of animal matter; whilst the bones dug up at Trasimenè or Herculaneum differ very little from recent bones.

These remains of viviparous quadrupeds, found in the diluvian strata, most curious in their nature, appear to have belonged to animals which no longer exist. Cuvier, to whose genius we owe all the great elucidations of this mys-

terious subject, has found that amongst upwards of seventy varieties of animals, discovered in these strata, eleven only bear a perfect resemblance to species now existing, and by far the greater number belong to unknown species, and more than thirty to new genera; and it is remarkable that the species resembling those which now inhabit only warm climates, are found in the fossil state in cold ones; the bones, and even the entire body and skin, of the elephant and rhinoceros, in Siberia; and the bones of elephants, hippopotami, hyænas, and animals of the tiger kind, in these islands and over the continent of Europe.

It has generally been admitted by sound reasoners, that the manner in which these bones are found buried amongst gravel, sand, and water-worn stones, proves the operation of a great diluvium—an inundation of the waters of the ocean over the land. But, till Professor Buckland's paper, there had been no decisive evidence, though there had been reasonable conjectures, that these animals once existed in the countries in which their remains are now found, and that they had not been transported by the violence of the inundation or of currents acting under very peculiar circumstances, from other climates, such as those now inhabited by the same species of animals.

As far as Yorkshire and England are concerned, and analogy would induce us to conclude, the whole of Europe and the northern continent, Professor Buckland has shown, by

fair inductive reasoning, that a large species of hyæna, the rhinoceros, the hippopotamus, the elephant, and animals of the bear and tiger kind, once inhabited this country; and he infers, with some degree of probability, that they were destroyed by the deluge. Since Professor Buckland's paper has been published, I have had the pleasure of visiting the cave, in his society, and entertain no doubt of the general accuracy of his conclusions. The horizontal nature of the fissure,—the immense quantity of bones and teeth found in it,—the manner in which they are worn on one side,—the marks made by the gnawing of teeth in many of them,—the excrements of the animal,—all prove the circumstance of the cave having been inhabited by hyænas, probably, by many generations; who brought in from the neighbourhood, such animals as they could destroy, or such as, found dead, they could tear into pieces.

You will, I am sure, consider it as a fortunate circumstance, that such a phenomenon occurred to so accurate an observer as Professor Buckland. The nature of the cavern rendered it inaccessible, except in quarrying the rock; fortunately it was closed by stalactite, and the bones were covered with mud, which prevented the action of the included atmosphere upon them, and, consequently, their decomposition: and thus they remained, almost in their primitive state and positions, sealed up,—a faithful record, as it were, of a past age of the world.

Since your last session, Professor Buckland has examined various caves in different parts of Germany, containing bones; and the cavity in the limestone rock at Oreston, near Plymouth; of which an account had been formerly published in your *Transactions*, and has confirmed his general conclusions, concerning the period at which the animals, to whom the bones belonged, lived, and their destruction by a great inundation of water. But I shall not anticipate his views, as I hope he will himself lay them before the Society.

The existence of animals, of genera now only found in warm climates, being established, it becomes a curious inquiry, whether our temperature has been changed, or whether the difference in the species, and consequently the habits, was such as to enable them to live in temperate or cold climates. Professor Buckland, with his characteristic caution, has not decided on this question. The ancient hyæna, elephant, and hippopotamus of this country were, perhaps, as different from those of Africa, as the musk ox is from the common ox; yet, supposing the antediluvian climate of Siberia such as it is now, it is difficult to imagine, that an animal of the elephant species could have found sufficient food there, or that a hippopotamus could have inhabited its frozen rivers.

It seems much more likely, that the temperature of the globe has been changed; and, perhaps, suddenly, by a great irruption of water from a deep ocean over the land.

An ancient higher temperature of the globe is likewise not only consistent with this view of the subject, but likewise with the late observations made on the heat of the interior, and with the facility afforded by it of explaining many existing phenomena, and many mineral productions. I shall not, however, indulge in any speculations on this subject, which no person is more capable of illustrating than the worthy Professor himself.

I cannot conclude this part of my subject without congratulating the Society, that by these inquiries, a distinct epoch has, as it were, been established in the history of the revolutions of our globe: a point fixed, from which our researches may be pursued through the immensity of ages, and the records of animated nature, as it were, carried back to the time of the creation.

It is gratifying to feel that the progress of science establishes, beyond all doubt, the great catastrophe described in the sacred history, and the account of which is blended with the traditions of so many ancient nations; and that it likewise demonstrates the circumstance of a primitive chaotic state of the globe, in which there was no life, of a successive creation of living beings, of which man was the last, destined to people the earth, when its surface had assumed a state of order and beauty fitted for the improvement and activity of an intellectual and progressive being.

In comparing such deductions of geology with some bril-

liant speculations of the last century, it is impossible not to smile at the aberrations of human genius, and to be proud of the progress we have made.

The eternal order of one simple system, in which the same beings, slightly changed, existed, and in which water is the destroying and fire the renovating principle, though supported by so much talent, fact, and experiment, has disappeared, for the sound geologist, with the more visionary ideas of the earth's being originally a portion of the sun; and of organized germs passing, in the immensity of time, through the different stages of improvement, rising from fishes, through mermaids, quadrupeds, and apes; and, at last, perfect in man!

Hypotheses and dreams of this kind are now rejected; and so ought to be all those views, in which systems of geology are attempted to be framed out of the sacred writings, by wresting the meaning of words, and altering the senses of things. Lord Bacon long ago raised his voice against this mode of proceeding: grand facts in the history of the globe are given, but not systems of philosophy. Man has no right to measure divine truths by his own fancies or opinions: they should be kept perfectly distinct. The more we study nature, the more we obtain proofs of divine power and beneficence; but the laws of nature and the principles of science were to be discovered by labour and industry, and have not been revealed to man; who, with respect to phi-

losophy, has been left to exert these god-like faculties, by which reason ultimately approaches, in its results, to inspiration.

Mr. Buckland,

Receive this medal as a proof of the high estimation in which your labours and researches are held by a body which, I believe, is very impartial in its decisions, and which, I trust, looks to the actual progress science has made, rather than the person, school, or nation, to whom it has been owing. I know I need not urge *you* to a further pursuit of these inquiries, by which you have gained distinction, and so much merited popularity. You are, I am sure, devoted to them, and I only wish you health to enable you to pursue them; for I am convinced that the longer you live, the more extended will be the obligations you will confer on the world of science: I hope your example will stimulate some of the younger Fellows of the Society to similar researches. It is, as it was originally, *the Royal Society for the improvement of natural knowledge;* and we have been, and always are, most happy to receive important facts, laws, and principles, respecting the mineral history of the earth. We deeply feel the use and the importance of such inquiries, in their relations to the progress of the arts, as well as to the sublimer speculations of philosophy. How intimately, for instance, is agriculture, on which nations depend for their

powers of supporting and multiplying a happy population, connected in its progress with the knowledge of the nature of soils, of the sub-strata and strata of the earth, and of fossil manures! How much is architecture, next perhaps in utility, dependent for its resources upon an acquaintance with the nature and situation of stony substances, necessary for permanent structures, and those qualities of them which occasion their decomposition or their permanency! And how great a part of the actual strength, as well as the wealth of countries, depends upon their metallic and mineral veins and strata,—upon their coal and their iron, which, applied by chemical and mechanical ingenuity, have, as it were, caused the elements to labour for man!

Nor is this study, as no one has better explained than yourself, without its moral benefits, affording happy views, where they might least be expected, of the economy of nature: the great mountain-chains equalizing the temperature of the globe, and, by their elevation, rendering warm climates habitable; the ocean being a reservoir of heat, and the rocky strata serving not merely as the support of soils, but causing a distribution of the water poured down from the atmosphere, for the purposes of vegetable and animal life. Then, in the history of the past changes of the globe, what a sublime subject is there for the exercise of the imagination!

If we look with wonder upon the great remains of human

works, such as the columns of Palmyra, broken in the midst of the desert, the temples of Pæstum, beautiful in the decay of twenty centuries, or the mutilated fragments of Greek sculpture, in the Acropolis of Athens, or in our own Museum, as proofs of the genius of artists, and power and riches of nations now past away; with how much deeper a feeling of admiration must we consider those grand monuments of nature, which mark the revolutions of the globe: continents broken into islands; one land produced, another destroyed; the bottom of the ocean become a fertile soil; whole races of animals extinct, and the bones and exuviæ of one class covered with the remains of another; and upon these graves of past generations, the marble or rocky tombs, as it were, of a former animated world, new generations rising, and order and harmony established, and a system of life and beauty produced, as it were, out of chaos and death; proving the infinite power, wisdom, and goodness of the Great Cause of all being!

DISCOURSE OF THE PRESIDENT

ANNIVERSARY, DEC. 1ST, 1823,

ON THE CHARACTERS OF DR. HUTTON. DR. JENNER, DR. BAILLIE, COLONEL LAMBTON, ARCHDEACON WOLLASTON, DR. CARTWRIGHT, AND MR. JORDAN;

AND ON THE AWARD OF THE COPLEY MEDAL TO

JOHN POND, ESQ.,

ASTRONOMER ROYAL,

FOR HIS VARIOUS PAPERS ON SUBJECTS OF ASTRONOMY, PUBLISHED IN THE PHILOSOPHICAL TRANSACTIONS.

WITH GENERAL VIEWS OF THE PRESENT STATE OF ASTRONOMY, AND ON THE ACCESSIONS MADE TO THIS BRANCH OF SCIENCE, IN THE ROYAL OBSERVATORY AT GREENWICH.

After perusing this list of deaths I cannot avoid saying a few words on the characters of some of the Fellows whom we have had the misfortune to lose. Of course I can only speak of such as, by their communications to the Society or philosophical labours, have promoted the progress of science. Those who have other claims to public consideration will receive their applause in other places. Here a tribute of respect to the memory of the dead, who have promoted the objects of the Society, is called forth by gratitude, and it may perhaps awaken a feeling of emulation in the living.

The labours of more than half a century, Gentlemen, have established the reputation of Dr. Hutton, as one of the most able mathematicians of his country and his age.

His papers published in the *Transactions* of the Royal Society on Converging and Infinite Series and Cubic Equations, and his elementary and original works on various branches of the science of quantity, prove the extent of his

knowledge, his industry, and his penetration. And, during the long period that he was Professor at Woolwich, he may be regarded as having eminently contributed to awaken and keep alive that spirit of improvement among the military students which has so much exalted the character of the British officer, and which has been attended with such beneficial results to the country. Dr. Hutton's merits as an experimental philosopher were of no mean kind, and they are displayed in his paper on Gunnery, for which he was rewarded with the Copley Medal, by the President and Council of the Royal Society, in 1778. In this paper he extends the views and inquiries of Robins by many difficult and delicate experiments on the force of gunpowder, and draws conclusions which have been connected with important practical results. But perhaps Dr. Hutton's greatest work was his calculation of the density of the earth, founded upon Dr. Maskelyne's experiments of the effect of the attraction of Schehallien on the plumb-line, in which a simple quantity was to be discovered by the most complicated arithmetical processes, and which required great devotion of time and labour. His name, on this occasion, will ever be associated with one of the grandest and most important physical problems solved in the last century, and will pass down with honour to posterity.

Dr. Hutton, as you well know, died at a very advanced

age, and retained the vigour of his faculties. Nothing, indeed, can be a stronger proof of this than his paper communicated to the Royal Society in 1821, when he was eighty-four years of age, and which contains a comparison of Dr. Maskelyne's and Mr. Cavendish's experiments on the density of the earth, and a number of corrections of very difficult and intricate calculations.

To speak of Dr. Edward Jenner as a man of science of our own particular school, would be saying little; he has a higher claim to our deep regret and profound admiration, as a benefactor to mankind in general.

It is needless for me, Gentlemen, to dwell upon the effects of vaccination, but I may say something of the nature of the discovery. It often happens, that when by enterprise, ingenuity and unwearied application to one train of thought or experiment, some great step is made in practical or theoretical science, persons of common minds, in considering the simplicity of the result, are apt to undervalue the labour by which it was attained, and to refer to accident what has been really effected by the highest operations of the human understanding. That persons who had passed through a certain disease communicated by cattle, were not liable to variolous infection, had perhaps been known amongst the vulgar for more than a century; but without the investigation of Jenner, this knowledge would have remained hidden from the

scientific world, and perhaps been regarded as a vulgar prejudice. Lord Bacon has said, "there are short methods for men of genius;" but it might, perhaps, with more propriety be said, there are *new* methods for men of genius. Their characteristic is, that they do not walk in beaten roads, and that in seeing an object before them they are neither deterred by danger or the fear of ridicule, from following it through unfrequented paths. The originality of Dr. Jenner's mind and his accuracy of observation are shown in his first communication to the Royal Society, on the natural History of the Cuckoo; and, in pursuit of his great object, he met with obstacles which it required no ordinary degree of perseverance and of confidence in his own powers to overcome.

The fair way of judging of the merits of an inventor, is by the operation of his discovery in civilized and social life; and in this respect Dr. Jenner stands almost alone, having subdued a positive evil, having secured a benefit not only for all the present inhabitants of the earth, but for their most remote posterity: gaining for his name the most enviable kind of immortality, that connected with the gratitude and blessing of his fellow-creatures, and which will be more valued in proportion as men estimate more correctly the nature of true glory.

It is difficult, in speaking of those with whom we have been connected by ties of friendship, whom we have admired

and reverenced, to be strictly impartial; yet I believe that the merits of Dr. MATTHEW BAILLIE can hardly be estimated too highly, even by those who had the warmest feelings of affection for his memory. Whether considered as a physician or as a man, his talents and his virtues were alike distinguished. His works show the accuracy and coolness of his judgment, his minuteness of observation, and his acuteness in referring effects to their true causes, amidst the complicated phenomena offered by diseased organs. Whoever heard him give his opinion in the Council of the Royal Society was struck by the clearness and simplicity of his details, and the happy manner in which he caught the relations and explained the nature of a scientific subject in which he was interested.

Those who have seen him by the bed-side of the sick, who witnessed the kindness of his nature, the deep interest that he took in the sufferings and danger of his patients, will, above all, estimate the nobleness and disinterestedness of his conduct. An honour to his profession in public life, he was most amiable and exemplary in his intimate social relations and domestic habits. No man was ever freer from any taint of vanity or affectation. He encouraged and admired every kind of talent, and rejoiced in the success of his contemporaries. He maintained, even at court, the simplicity and dignity of his character. His greatest ambition was to be considered as an enlightened and honourable

physician. His greatest pleasure appeared to be in promoting the happiness and welfare of others.

With respect to Colonel WILLIAM LAMBTON, a veteran in the army of India, and who was personally known to very few Fellows of the Society, I can speak only of his works, and refer you to the two papers published in the *Transactions*, on the Admeasurement of an Arc of the Meridian in Hindostan, a work of great labour, displaying minute accuracy and extraordinary perseverance, and carried on in a climate unfavourable to bodily exertion or intellectual pursuit. This arc extends in amplitude nearly 10°, upwards of 9° 53′, from Cape Comorin to Namthabad; and Colonel Lambton has the honour of having laid down the largest connected portion of the meridian ever measured upon the surface of the globe; a work not only of importance in its relation to the figure of the earth, but constituting the foundation for a correct survey of our extensive possessions in India.

Of ARCHDEACON WOLLASTON, whose recent and sudden death has occasioned so much affliction to his family and friends, I can only say, that the little he communicated to the Royal Society makes us feel regret that he was not a more frequent contributor to our *Transactions*. His paper on the Measurement of Heights, by the Alteration of the boiling Temperature,

offers a valuable resource in ascertaining the altitude of mountains, and is remarkable for accuracy of method and distinctness of detail. I have always understood, that as a Professor in the University of Cambridge, his lectures were admirable; and he was worthy of a family in which talents and virtues seem to be hereditary.

Dr. CARTWRIGHT became a Fellow of the Society late in life. He was a very amiable man, possessed of literary talents, much mechanical ingenuity, and great enthusiasm in the exercise of it; and he received a parliamentary reward for a mechanical invention which, I believe, has been of considerable use to the manufactures of the country.

Mr. JORDAN was attached to science, and pursued with ardour a branch of optics, on which he published a work; he had the merit of attending to philosophical subjects amidst the duties of a profession which is rarely associated with scientific habits. No communications either of Dr. Cartwright or Mr. Jordan have been published in your *Transactions*.

COPLEY MEDAL.

From the melancholy office of speaking of the merits of your deceased Fellows, I now pass to the more pleasing

duty of stating the useful labours and active exertions of a living philosopher.

Your council, Gentlemen, have awarded the medal of Sir Godfrey Copley's donation, for the year 1823, to John Pond, Esquire, Astronomer Royal, for his various papers and observations communicated to the Royal Society.

The merits of Mr. Pond, as an indefatigable scientific observer, are fully and justly estimated by all the Fellows of this Society, who have visited or taken any interest in the Royal observatory; but, perhaps, the early devotion of the Astronomer Royal to his favourite science, the enthusiasm with which he pursued it, and the sacrifices of time, health, and money that he made in consequence, may be less generally known.

Twenty-five years ago, Mr. Pond, animated by his love of astronomy, carried, at a considerable expense, some valuable instruments to the coasts of the Mediterranean, hoping that a purer atmosphere and a brighter sky would give him advantages for pursuing continued observations on the fixed stars, not to be obtained in the variable climate of this island, and he passed some time devoted to his scientific objects at Lisbon, Malta, and Alexandria; but the state of his health obliged him to return, and he established himself at Westbury, in Somersetshire, where, in 1800, I had the pleasure of visiting him, and when I was delighted to witness the ardour with which he pursued his inquiries, and saw with

admiration, the delicacy of his observations with the astronomical circle of Mr. Troughton's construction.

The researches made at Westbury, by Mr. Pond, on the declinations of some of the fixed stars, in 1800, and published in the *Philosophical Transactions* for 1806, fixed the attention of astronomers by their accuracy, and the clearness of the details, and probably principally caused those scientific recommendations which inclined our august Royal Patron, then Prince Regent, to appoint him to the distinguished office which he now holds.

Since Mr. Pond has been Astronomer Royal, his communications to the Royal Society have been numerous, and many of them of great importance.

I shall mention some of the most considerable:—

In 1813, A Catalogue of the North Polar Distances of thirty-four of the principal Fixed Stars, deduced from Observations made with the Mural Circle, at the Royal Observatory.

In 1815, Determination of the North Polar Distances, and proper Motions of thirty Fixed Stars.

In 1817, Three Papers on the Parallax of the Fixed Stars.

In 1818, On the different Method of constructing a Catalogue of the Fixed Stars: on the Parallax of α Aquilæ, and on the Parallax of the Fixed Stars in right Ascension.

In 1823, Three Papers on the Changes that have taken Place in the Positions of some of the Fixed Stars, and a Paper on the Parallax of α Lyræ.

It is very difficult, or almost impossible to point out the specific merits of astronomical observations. They are not like philosophical or chemical experiments, which produce an immediate result; their delicacy and exactness can only be judged of by persons who have seen the manner in which they are made, and who are accustomed to the same kind of labour. They often relate to long periods of time, and their correctness and value can only, perhaps, be fairly estimated by posterity.

The two principal points of discussion in these papers of the Astronomer Royal, are, the grand and long-agitated question of the parallax of the fixed stars, and an apparent declination or change of position in a number of the stars, not to be accounted for by any known laws.

Since the Copernican system was first received as the true system of the universe, by the enlightened philosophers of Europe, the inquiry, whether the fixed stars had any annual parallax, has been constantly brought forward.

It was evident that the diameter of the earth would not afford any difference of angle with bodies so immensely distant as the stars, but it was hoped, that such a difference would be observed at the two extremities of its annual orbit, distant from each other nearly one hundred and ninety millions of miles.

Flamstead supposed he had observed a considerable annual parallax; but the observations of Bradley proved that the

phenomena which he described, were owing to another cause, and he solved them by his grand discovery of the aberration of light. The subsequent observations of Bradley, with the great sector constructed by Graham, the instrument that he had likewise used in his former researches, led to no result favourable to parallax; and the minute and accurate observations of the late Astronomer Royal, were on the same side of the question.

Between 1800 and 1806, Piazzi imagined that he had proved a parallax of some seconds, and Dr. Brinkley, in 1810, communicated through Dr. Maskelyne, his observations on α Lyræ, made with the great eight feet Dublin circle, and which, he conceived, showed that the parallax of that star could not be less than $2''$ or $2\frac{1}{2}''$. This star, and other stars, have been observed with great accuracy, by Mr. Pond; and his conclusions, both from the use of a fixed instrument and of the great circle, are, that none of the fixed stars which have come under his observation, have any sensible parallax, and that the parallax of α Lyræ, if it exist at all, cannot exceed a very small fraction of a second; his general conclusions are thus stated by himself: "The observations of this year have produced on my mind a conviction approaching to moral certainty. The history of annual parallax seems to be this—in proportion as instruments have been imperfect in their construction, they have led observers into the belief of sensible parallax: this has happened in Italy to astro-

nomers of the very first reputation. The Dublin instrument is superior to any of a similar description on the continent, and, accordingly, it shows a much less parallax than the Italian astronomers imagined they had detected.

"Conceiving that I have established, beyond a doubt, that the Greenwich instrument approaches still nearer to perfection, I can come to no other conclusion, than that this is the reason why it discovers no parallax at all."

Dr. Brinkley has not yet replied to Mr. Pond's latest examination of this subject; but in an elaborate paper, published in the *Transactions* for 1821, he enters into a full discussion of the question, and displays, as usual, the most profound views of the causes which may affect his observations, and the greatest acuteness in examining the objections that have been made to his conclusions, and he endeavours to confirm them by new observations, and is still of opinion, that many of the fixed stars have a sensible parallax. In awarding the medal to Mr. Pond, the Council of the Royal Society do not at all mean to express an opinion on this subject: when two such astronomers differ, it would be presumptuous, and almost impossible, for them to decide; it is, however, highly satisfactory to know that the question is now reduced within such very small limits, the difference between the Greenwich and the Dublin observations generally amounting to less than a second. Those who read Dr. Brinkley's and Mr. Pond's papers with attention, can alone

judge of the refinements of modern observation, and of the perfection to which the genius and labour of Mr. Troughton have carried our instruments, and of the extreme difficulty and delicacy of this investigation, in which the smallest differences of temperature, and (when stars are not in the zenith) of the refractive power of the atmosphere, produce immense results, and where perfect stability of the instrument of the building, and of the ground on which it stands, are absolutely essential.

With respect to the second great point in Mr. Pond's papers, the apparent variation in the position of many of the fixed stars; the novelty of the subject and the great importance of its relations, and the very short time that has elapsed since it has been brought before the Society, and the necessity for its confirmation by the observations of a long series of years, so as to discover the true cause, render it impossible for me to do more than state the supposed result, and the manner in which it was obtained.

You will well remember the candour with which the Astronomer Royal communicated to the Society the account of an accident which had happened to the mural circle. In examining the supposed errors in the places of fixed stars owing to this accident, he at first rated them high; but after the instrument was put in a state of perfect repair, he found, by the most delicate observations, that a part of what he considered as error, appeared to be really owing to a southern

declination of many of the principal fixed stars, and that their real places were considerably further south than their predicted places, as discovered by ancient catalogues. After considering the subject under every point of view for more than twelve months, and examining the most correct catalogues, the Astronomer Royal is still of the same opinion on this subject, and he considers this apparent change in the position of the principal fixed stars, as incapable of being accounted for from any source of error in the instrument or mode of observation, and as pointing out to some unknown and new principle. However improbable this may at first view appear, it will be recollected by the Fellows of this Society, that the first germs of the great discoveries of Bradley,—the Aberration of Light, and the Nutation of the Axis of the Earth,—were observations of this kind, but nearly a quarter of a century was required for the full developement of these grand truths.

Should the southern declination be ultimately established, a motion towards, or slow revolution of the sun round some part of the sidereal world, seems a much more probable cause of explanation than any new unexplained relations of the system to light, or any unknown motion of the axis of the earth, or any proper motion, in one direction, of the great body of the stars. But these are points for future discussion, upon which no man is more able to enter than the Astronomer Royal himself; let us hope that he will verify,

and place beyond doubt, this important but still uncertain result, and that it will lead to a new law in nature, and add another important discovery to those which we already owe to the labours carried on in the Royal Observatory, and which have so much contributed to the progress of astronomy, and to the glory of our country.

I cannot touch upon this subject without saying a few words more, for it is one which ought to call forth feelings of gratitude and admiration in every Fellow of this Society.

How distinctly the results obtained there prove the utility, almost necessity, of the foundation and the patronage of some such establishments by government; for since the existence of this noble Institution, what lasting benefits has it conferred on science and the public!

I remember the late excellent Secretary of the Royal Academy of Sciences at Paris, said to me, in conversation ten years ago, "such is the excellence and extent of the Greenwich observations, that if all the other records of science were destroyed, they alone would be sufficient to found a system of astronomy."

In going back to Flamstead's time, we find them taken by all Europe as the models to be followed in similar establishments. Of Halley, a philosopher of a higher stamp, and inferior, perhaps, only to his friend and master, Newton, it is scarcely possible to speak with sufficient praise. The observations of the transits of Venus, the determination

of the solar parallax, the investigation of the Newtonian law of cometary motions, and the prediction of the return of the comet of 1682, in 1759, the foundation of the method for observing the lunar motions, and the accurate observations of that satellite for more than nine years,—labours which have led to the construction and perfection of those tables which are of such immense importance to navigation, and which may be said to have given us the discovery of the longitude at sea,—are a few amongst the obligations of astronomy to this great man.

Of Bradley, it may with truth be said, that he was worthy to succeed Halley, and his name is immortalized by the two most important discoveries ever made with respect to the system of the heavenly bodies.

Of Dr. Maskelyne, whom we remember with so much respect and affection, it is only necessary to say, that his was a kindred spirit to that of those illustrious philosophers; and whether determining the density of the earth in his shed on Schehallien, or observing the fixed stars with unwearied attention at Greenwich, he was always the same patient, acute, sagacious, and unprejudiced observer.

Without an establishment provided by the liberality of government, without that retirement and philosophic leisure afforded by their situation, without instruments requiring an expense which few individuals can command, these distinguished men might almost have been born in vain; and

what a recompense has been bestowed on the nation for the few hundreds of pounds annually devoted to this object! The greatness of this country has arisen with its maritime and colonial empire; and how much has the Royal Observatory done for the perfection of navigation and the interests of our navy! A misfortune like that by which one of our noblest fleets and bravest admirals were lost on the Rocks of Scilly, not much more than a century ago, can now never happen again; and independent of the common question of utility, what an immense effect has the progress of astronomy, following and confirming those views of the system of the universe of our own illustrious Newton, had upon the improvement of general science, thus enlightening and exalting the human intellect! All the superstitious notions, all the prejudices respecting the heavenly bodies, which had such an effect upon the destinies of individuals and of kingdoms in ancient times, have disappeared. Man, acquainted with his real situation in the scale of the universe, has learned to appreciate his objects, and the ends of his creation. A mere drop in the ocean of infinity, he has yet sufficiently felt his divine and intellectual nature, to elevate his mind from the minute base of the earth to the heavens, to investigate the laws of bodies invisible to him except by instruments of his own invention, and hundreds of millions of miles removed from him. And, in the progress of his knowledge, he has seen obscurity vanish, motions which, considered for a short

space of time appeared disorderly, he has found belonging to an extensive and regular cycle; and in what seemed sources of confusion and imperfect machinery in the constitution of things, as new lights have poured in upon him, he has found causes of order and harmony. So that modern astronomy, as it now exists, is the noblest monument ever raised by man to the glory of his Maker: for its ultimate and refined developements demonstrate combinations which could only be the result of infinite wisdom, intelligence, and power.

Mr. Astronomer Royal,

I now present to you this medal as a token of the respect of the Society, and of the confidence of the Council in the great accuracy of your observations, and likewise as a memorial that future important labours in the same department of science are hoped for, nay expected, from you.

I am well aware that some of the greatest and most important objects of discovery, and those perhaps most obvious, have been obtained by the labours of your predecessors, and that in proportion as the field is investigated, new results become rare, as well as more difficult to be discovered; yet nature is inexhaustible, and the powers and resources of the human mind, and the refinements of art, have not as yet attained their limits. Who would have anticipated, half a century ago, the discoveries of Herschel and Piazzi?—Though pursuing a science that may be considered as in its

maturity, you have advantages of a peculiar kind, more perfect instruments than were ever yet employed, more extensive assistance than any of your predecessors; and upon these points, the liberality and promptitude with which government have entered into your views, and those of the Council of the Royal Society, for the improvement of the Royal Observatory, cannot be too much admired. Continue to pursue your honourable career, and endeavour to be worthy of having your name transmitted to future generations with those of your illustrious predecessors.

Of all the branches of science, astronomy is that from which this Society has gained most glory; and it never has lost, and I am convinced never will lose, any opportunity of advancing its progress, and honouring its successful and zealous cultivators.

DISCOURSE OF THE PRESIDENT,

ANNIVERSARY, 1824.

CHARACTER OF BARON MASERES.

AWARD OF THE COPLEY MEDAL

To The Rev. Dr. BRINKLEY,

NOW BISHOP OF CLOYNE,

FOR HIS MATHEMATICAL AND ASTRONOMICAL PAPERS, PUBLISHED IN THE PHILOSOPHICAL TRANSACTIONS.

WITH

VIEWS ON SOME REFINED QUESTIONS OF ASTRONOMY, AND ON THE GENERAL IMPORTANCE AND SUBLIME VIEWS OF THIS SCIENCE.

In reading over this list, though there is one person of extraordinary genius*, still an object of deep interest in the literary world, and though other names occur connected with useful professional labours, yet the only character which I am called upon to notice, as a contributor to your *Transactions*, and as an active scientific member of the Society, is that of Baron Maseres. He may be considered as belonging to the old mathematical school of Britain; and through a long life devoted much of his leisure and a portion of his fortune, to the pursuit and encouragement of the higher departments of algebra and geometry. Four of his papers are published in your *Transactions*,—two on Infinite Series, and two on the Extension and Discovery of Cardan's Rule. He printed, at his own expense, the *Scriptores Logarithmici*, and an extensive and laborious work on *Negative Quantities*, in which he took a very peculiar view of this abstruse subject. He was fonder of investigating the principles of the mathematical sciences, than of attempting applications of them. His love of science was of the most

* Lord Byron.

disinterested kind, as is shown by the nature of his publications, and by the liberal way in which he encouraged the publications of others. He died in extreme old age, having almost outlived his faculties.

Copley Medal.

In following the course of the business of the day, I have to announce to you the decision of your Council with respect to the medal of Sir Godfrey Copley's donation to the Society.

It has been awarded this year to the Reverend John Brinkley, D.D. Andrew's, Professor of Astronomy in the University of Dublin, and President R. I. A., for his various communications printed in the *Philosophical Transactions.*

To some of the members of the Society, who have not followed closely the usages of the Council, a question might at first sight arise upon the decision, why in two successive years the cultivators of a science, which, during that time, has been distinguished by no remarkable discoveries, should receive the highest honours which this Philosophical Association has to confer.

A very short explanation will, I trust, suffice. The progress of science has no annual periods; and when a medal is to be bestowed every year, not merely important scientific

facts, but likewise trains of useful labours and researches must be considered; and the zeal, activity, and knowledge of those persons, who, having been contributors to your *Transactions*, must be regarded as competitors, are to be taken into the account.

It has now and then happened that the Royal Society has had the felicity to mark some great and brilliant discovery, such as that of the aberration of light, or the magnetic effects of electricity, by this token of its respect; but in general, of necessity, the medal is bestowed for contributions of a more humble character. To reward those laborious philosophers who enlighten science by correct observations or experiments, or those sagacious inquirers who by accurate reasonings or ingenious views, lay the foundation for new researches, new theoretical arrangements, or applications of science to the uses of life; and if any one department of natural knowledge requires encouragement more than another, it is astronomy; for having arrived at a mature state, and presenting few striking objects of discovery, it can only be perfected by the most minute, laborious, and delicate inquiries, which demand great attention, great devotion of time, and which must often be carried on at a period usually destined to repose, and often with the sacrifice of health.

Whoever considers these circumstances will, I am convinced, be satisfied of the justice of this vote of your Council.

Dr. Brinkley has long been known as an enlightened and profound mathematician. His labours, published in the *Memoirs of the Royal Irish Academy*, contain abundant proofs of his skill in the higher departments of analysis, but it is not necessary to look anywhere else for a demonstration of this, than in our own *Transactions*. The volume for 1807 contains an important paper, on the General Term of a Series in the Inverse Method of finite Differences; in which, taking up a subject of investigation on which both Lagrange and Laplace had written, he has surmounted a difficulty which had remained even after the investigations of these illustrious geometers.

Whoever is in possession of the higher resources of the mathematical sciences, may be considered as gifted with a species of power applicable to every department of physical knowledge. It is indeed for this species of knowledge, what muscular strength is for the different branches of human labour; it not only generalizes the results of experiment and observation, but likewise corrects them, and leads to new and more refined methods of investigation. The guide of the mechanical and pneumatical philosopher, and the useful assistant of the chemist, it is of still more importance to the astronomer, whose results depend entirely upon magnitude, time, and motion.

Endowed in so high a degree with one of the essential characters of an accomplished astronomer, his various later

communications to the Royal Society, show that Dr. Brinkley is equally distinguished as a laborious, acute, and accurate observer. Your *Transactions* contain seven of his papers, on pure astronomical subjects:—

The first, On the Parallax of α Lyræ.

The second, On the Parallax of certain Fixed Stars.

The third, The Results of Observations made at the Observatory of Trinity College, Dublin, for determining the Obliquity of the Ecliptic, and the Maximum of the Aberration of Light.

The fourth, An Account of Observations made with the eight-feet Astronomical Circle since the beginning of 1818, for investigating the Effects of Parallax and Aberration on the Places of certain Fixed Stars; also the Comparison of them with former Observations for determining the Effects of Lunar Nutation.

The fifth, On the Elements of the Comet seen by Captain Basil Hall at Valparaiso.

The sixth and seventh, two papers communicated in the last year,—the first, On the North Polar Distances of the principal Fixed Stars,—the second, Additional Observations on the Parallax of α Lyræ.

Of the high merits of these communications, there is, I believe, but one opinion amongst competent judges, not merely at home, but (I can speak from my own immediate knowledge,) likewise abroad.

Dr. Brinkley has taken up no difficult object of research, without first satisfying himself of the correctness of his instruments by numerous preliminary and delicate trials. He has likewise, in forming his conclusions, examined with philosophical precision all the circumstances which may interfere, and he states the results with the utmost candour, creating difficulties for himself, and proceeding with the greatest caution in these fields of inquiry which had been already entered in vain by so many illustrious men.

You well know, Gentlemen, that Dr. Brinkley and the Astronomer Royal are at issue on two great and leading questions of Astronomy—first, the sensible parallax of some of the Fixed Stars,—and secondly, on the apparent southern motion or declination of parts of the sidereal system. You know that sensible parallax is denied by Mr. Pond, and believed to exist by Dr. Brinkley; that, on the contrary, the southern declination is denied by Dr. Brinkley, and believed to exist by Mr. Pond.

I mentioned, in announcing the award of the medal last year, that the Council of the Royal Society had no intention of giving its sanction to the opinions of the Astronomer Royal, or of attempting to decide on these important and difficult questions. I again feel it my duty to make the same reservation on this occasion, and to state that the general labours of Dr. Brinkley, on the most difficult parts of astronomy, and the approximation to the solution of a great

problem, and the high merits of his philosophical inquiries, are the sole grounds on which the Copleian medal has been bestowed.

The Council could not with propriety form an opinion on these subjects, when two such astronomers, possessing such peculiar qualities for observation, and such varied and exalted resources, are at variance; and the difficulty and delicacy of the questions, will perhaps be fully perceived by the addition of some short details to those given last year on these obscure branches of sidereal astronomy.

When Copernicus first developed that sublime system of the planetary worlds which has since been called after his name, he was obliged to suppose the fixed stars at an almost infinite distance; and the astronomical instruments of that day offered no means even of attempting the discovery of their parallax. The importance of such a discovery was, however, immediately felt, as a demonstration of it would, in fact, become likewise an absolute demonstration of the Copernican system of the universe.

Galileo seems to have suggested the method of inquiry for parallax, by examining the relative position of double stars, at the two extremities of the earth's orbit; a method founded on the supposition that the stars differ greatly in distance. This method, likewise strongly recommended by Dr. Wallis, was first, I believe, practised and pursued with great sagacity and industry by Sir William Herschel: and

though it has furnished many important results, with respect to the proper motions of their stars, and the arrangement and groups of these heavenly bodies, it has as yet afforded no observations forming data for reasoning on the distance of the fixed stars from the sun.

The other method, and that which has been most insisted upon, seems likewise to have originated with the illustrious Florentine philosopher, that of observing stars about the summer and winter solstice in or near the zenith, for the purpose of avoiding the errors of refraction, by fixed instruments. The celebrated Robert Hooke, who erected at Chelsea a telescope thirty-six feet long, for examining γ Draconis, imagined that he had discovered a very considerable parallax for this star, but Hooke's observations were contradicted by those of Molyneux. Flamstead drew a similar conclusion from his experiments on the pole star, but the results which he ascribed to parallax, were explained by Bradley's great discoveries of the aberration of light, and the nutation of the earth's axis; and it is remarkable that Hooke reasoned correctly on inaccurate observations, while Flamstead formed wrong conclusions from exceedingly correct results.

James Cassini, in observing Sirius, attributed a parallax of six seconds to this star; and La Caille, from observations made at the Cape of Good Hope, supposed it four seconds.

Piazzi, in researches pursued from 1800 to 1806, supposed

that several of the fixed stars exhibit parallax. He assumes for Sirius nearly the same parallax as La Caille; for Procyon, three seconds; for Capella, less than a second. His conclusions are, however, given with great diffidence, and his object seemed to be, rather to call the attention of astronomers to a subject which had been for some time neglected, than to press his opinions upon them with anything like confidence.

In all these observations made upon the stars, it must be confessed nothing like southern motion had ever been suspected.

Dr. Brinkley, in his first communication to the Royal Society on Parallax, in 1810, rated it for α Lyræ, at two seconds and a half. The Astronomer Royal, in endeavouring to confirm this result, has had no satisfactory indications of such a fact; and his general conclusions, as you know, both from observations made with a fixed instrument, and with the mural circle, are unfavourable to the existence of sensible parallax for any of the fixed stars; and he refers apparent parallax to the imperfection of the instrument with which the observations have been made, and offers as a proof, the diminution of the indications in proportion as instruments have become more delicate; and estimating the Greenwich as superior to the Dublin circle, thus accounts for the difference of his results and those of Dr. Brinkley.

This gentleman, in his last three papers on Parallax, has

replied to all the arguments, and has endeavoured to overturn all the objections of the Astronomer Royal. He does not allow the superiority of the principle of the Greenwich instrument, and he shows the consistency of the Dublin instrument with itself, by thirteen summer solstices, for which observations on eighty-seven days were made, and which give the maximum of lunar nutation 9″. 60, exactly what he had used for the sun, and very nearly the same result as that from the stars; placing the permanent state of the instrument beyond all doubt. The results of two hundred and sixty-two observations on α Lyræ, in 1811, give the mean difference between the summer and winter zenith distances at 1″. 32; and repeated observations made in the last ten years, give sensible parallax, though with less consistency, for α Aquilæ, α Cygni, and Arcturus, but none for γ Draconis.

The minute accuracy with which Dr. Brinkley has investigated the subject, can only be estimated by accomplished mathematicians and astronomers. He has examined all Mr. Pond's results, reasoning upon the law of the aberration of light, the effects of refraction and of differences of temperature, and has compared his own series of observations with those of other astronomers, and he seems entirely convinced of the accuracy of his general conclusions. If any circumstances depending upon change of temperature, flexion of the instrument, or other causes of error existed,

"Why," he says, "should they not be general for all the stars?" "Why," he asks, "should such causes exist for α Lyræ, and not for the pole star, which shows no sensible parallax?"

In his last paper, he makes some further corrections in the co-efficient of aberration and solar nutation, and his ultimate result is $1''.14$ for the annual parallax of α Lyræ.

On the question of southern motion, Dr. Brinkley expresses himself with much more confidence than on that of parallax. He compares M. Bessel's, Mr. Pond's, M. Piazzi's, and the Dublin catalogues; and after endeavouring to prove a discordance in the Astronomer Royal's mode of applying the data in these catalogues to the question, he says, "from the weight of external testimony adduced, it will, I think, be readily conceded to me that the southern motion does not exist, and that it must be regarded as an error belonging to one or both of the Greenwich catalogues of 1813 or 1823."

Such is the state of these two questions.

They are not, however, questions of useless controversy, or connected with hostile feelings. The two rival astronomers seem equally animated with the love of truth and justice, and have carried on their discussions in that conciliatory, amicable, and dignified manner, which distinguishes the true philosopher. I cannot give a stronger proof of this, than in stating, that the Astronomer Royal was amongst the

first of the Members of the Council, to second and applaud the proposition for the award of this day.

I have said, that these questions are not questions of useless controversy, nor are they questions of mere curiosity. No important changes can take place in the sidereal system without affecting the whole of astronomy: the fixed stars are, indeed, to space in the heavens, what land-marks or the extremities of base lines are to distances upon the earth; and all our conclusions upon the great problems of the system of the universe, have been formed upon the idea of the general permanency of their arrangements.

With respect to parallax, it is not a little remarkable, that Dr. Bradley, from his varied and refined observations with Graham's sector, concluded that α Lyræ could not possess a parallax of as much as 2″, and that Dr. Brinkley's conclusions, from his most refined observations, come far within these limits. Mr. Mitchell, likewise, from photometrical considerations concludes, that if the largest fixed stars are the nearest, and about the size of the sun, their parallax, taken from the quantity of light they emit, can not much exceed one second; and Mr. Gauss, in a conversation that I had with him this summer, he informed me, that he had drawn a similar conclusion, from ascertaining the distance and size of the image of the sun upon the helioscope; the new instrument that has been used with so much success in triangulation.

There is one circumstance which seems to have perplexed Dr. Brinkley a little, namely, that some of the smaller stars seem to show a greater parallax than those of a larger apparent size: this, at first sight, might appear to throw some doubt upon the results; yet it, perhaps, admits of explanation, on the idea that if the stars are disposed in groups or systems, as Mr. Mitchell and Sir William Herschel believe, the bodies possessing the greatest masses, may be in the centre of these groups, and the smallest stars in consequence most contiguous to the largest. It is to be regretted, that on the subject of parallax, no star has yet been observed absolutely in the zenith, which might easily be done in a part of the globe, for instance, under the equator, when almost precisely the same circumstances of temperature, moisture, and pressure of the atmosphere, would constantly exist. An instrument fixed on granite, or an aperture made in a solid stratum of rock, would destroy the probability of interference from foreign causes, and reduce the problem to the simplest possible conditions.

In waiting for new elucidations on these important questions (and no persons are more capable of giving them than the two distinguished astronomers now engaged in the discussion), I cannot but congratulate the Society, that the state of scientific inquiry, and the number of scientific men, render it scarcely possible that any great problem can long remain unsolved, any considerable object of interest unin-

vestigated. No question is now limited to one observatory, to one country, or even to one quarter of the globe. While such men as Brinkley observe at Dublin, Bessel at Konigsberg, Arago at Paris, Olbers at Bremen, Schumacher at Altona, and Gauss and Harding at Gottingen, astronomy must be progressive, her results cannot but become more refined.

The observatories established by enlightened public patronage, at the Cape of Good Hope, and by private munificence at Paramatta, in New South Wales, cannot fail of giving us almost a new sidereal world in the southern hemisphere. Already, Sir Thomas Brisbane has sent to the Royal Society an extensive catalogue; and we may expect everything from him that indefatigable zeal, ardour of pursuit, and intense love of the science can afford.

With the increase of the popularity and the means of astronomy, facilities for procuring the necessary instruments, have likewise been greatly increased; and it must be a gratifying circumstance to the lovers of science to know, that even on the continent, extensive and accurate researches meet with no obstacle from the want of proper apparatus; and though Germany cannot boast of a Ramsden, a Troughton, or a Dollond, yet it possesses a Reichenbach, and a Fraunhofer, whose instruments even the Astronomer Royal, I am sure, would examine with pleasure.

All these circumstances ought to be subjects of congra-

tulation to us, not of uneasiness; and if they produce any strong feeling, it should be that of emulation and of glory; the desire of maintaining the pre-eminence which, since the foundation of the Royal Observatory, has belonged to us in this science. And, amongst the cultivators of the different branches of human knowledge, astronomers particularly, whose subject is the heavens, should be above the feelings of low, or even national jealousy: their results are for all nations, and for future ages, and they require even for their perfection, the peaceful co-operations of philosophers in the remote parts of the globe.

I cannot give a more happy instance of this, than the manner in which the comet, of the shortest known period, of M. Encke, was observed by Sir Thomas Brisbane's assistants, in New South Wales, and the calculations of its return so fully verified.

There is no more gratifying subject of contemplation than the present state and future prospects of astronomy; and when it is recollected, what this science was two centuries ago, the contrast affords a sublime proof of the powers and resources of the human mind. The notions of Ptolemy of cycles and epicycles, and the moving spheres of the heavens, were then current. The observations existing were devoted rather to the purposes of judicial astrology, than to the philosophy of the heavenly bodies, to objects of superstition, rather than of science.

If it were necessary to fix upon the strongest characteristic of the superiority of modern over ancient times, I know not whether the changes in the art of war, from the application of gunpowder, or in literary resources, from the press, or even the wonderful power created by the steam-engine, could be chosen with so much propriety as the improved state of astronomy.

Even the Athenians, the most enlightened people of antiquity, condemned a philosopher to death for denying the divinity of the sun; and it will be sufficient to mention, the idolatry and utter ignorance of the other great nations of antiquity, with regard to the laws or motions of the heavenly bodies.

Take the most transient and simplest view of the science, as it now exists, and what a noble subject for contemplation! Not only the masses and distances of the sun, planets, and their satellites are known, but even the weight of bodies upon their surface ascertained, and all their motions, appearances, and changes predicted with the utmost certainty for years to come, and even carried back through past ages to correct the chronology, and fix the epochas in the history of ancient nations. Attempts have been made to measure the almost inconceivable distances of the fixed stars: and, with this, what sublime, practical, and moral results! The pathless ocean navigated, and in unknown seas, the exact point of distance from known lands ascertained. All vague and superstitious

notions banished from the mind, which, trusting to its own powers and analogies, sees an immutable and eternal order in the whole of the universe, intended, after the designs of the most perfect beneficence, to promote the happiness of millions of human beings, and where the whole of created nature offers its testimony to the existence of a Divine and Supreme intelligence.

I shall now conclude: Mr. BAILY, you have been so good as to undertake to transmit the medal to Dr. BRINKLEY; no one is more capable of appreciating the high estimation in which his talents and character are held by the Royal Society. Assure him of our respect and admiration; inform him, that presiding, as he does, over another kindred scientific body, we receive his communications not merely with pleasure but with gratitude, and that we trust he will continue them, both for the advancement of astronomy, and for the increase of his own high reputation.

DISCOURSE OF THE PRESIDENT,

ANNIVERSARY, NOVEMBER 30TH, 1825.

CHARACTER OF MR. WILLIAM HIGGINS.

AWARD OF TWO COPLEY MEDALS:

ONE TO

M. ARAGO, F.R.S., M.R.A.S.P.,

FOR HIS DISCOVERY OF THE PROPERTY POSSESSED BY BODIES IN GENERAL TO BE AFFECTED BY MAGNETISM;

AND THE OTHER TO

MR. PETER BARLOW, F.R.S.,

PROFESSOR AT THE ROYAL MILITARY ACADEMY, WOOLWICH,

FOR HIS DISCOVERY OF A METHOD OF CORRECTING THE ERRORS OF THE COMPASS, ARISING FROM THE ATTRACTION OF THE IRON IN A SHIP.

I HAVE, hitherto, in concluding this painful part of my duty, (announcing the deaths,) usually taken some particular notice of such of the deceased members, as have either contributed to your *Transactions*, or promoted, by their publications, the progress of science; or have encouraged the pursuit by their personal exertions and social interest, at our meetings; but upon this occasion I have scarcely more than the general sentiment of regret to offer. Many of the gentlemen whose names I have read to you were learned and ingenious men, and one of them a most laborious and industrious compiler*: but however their loss may be regretted by their friends, yet they can hardly be said to have been known sufficiently to the scientific world to call for particular notice before this body. I may except, perhaps, Mr. WILLIAM HIGGINS, Professor of Chemistry to the Dublin Society, who published, nearly forty years ago, his *Comparative View of the Phlogistic and Antiphlogistic Theories*, which contains some ideas of great importance with respect

* Dr. Rees.

to what may be called the theory of definite proportions, or more commonly the atomic theory. He shows that bodies combine particle to particle, as 1 to 2 or 1 to 3, and so on; and he gives many very happy instances of such combination: but he brought forward no new experiments, and endeavoured to establish a loose kind of dynamic hypothesis. His work, however, contains many curious and ingenious views, and it is impossible not to regret that he did not establish principles which belong to the highest department of chemistry, and that he suffered so fertile and promising a field of science to be entirely cultivated by others; for though possessed of great means of improving chemistry, he did little or nothing during the last thirty years of his life.

Copley Medals.

It is now my duty to announce to you the decision of your Council with respect to the award of the Copleian medals.

The medal of this year's donation they have bestowed on M. Arago, Fellow of this Society, and Member of the Royal Academy of Sciences of Paris. And another medal, which was not disposed of on a former year, they have awarded to Mr. Peter Barlow, likewise a Fellow of this Society, and Professor in the Royal Military Academy at Woolwich.

The discoveries and labours which your Council have made it their pleasure and thought it their duty to honour, by conferring on their authors the highest rewards of this Society, belong to the same department of science—magnetism, a department which has always claimed a considerable portion of your attention, both in its relation to philosophy and utility—to the laws and properties of natural bodies, and to navigation, the great source of the power and prosperity of this mighty empire.

That I may be able more distinctly to state the grounds of the decision of your Council, I shall enter into a few historical details and general views on the subject, which I hope will not be unacceptable to our Fellows, not merely as setting forth the justice of the award, but as offering hopes of further discoveries, and as proving that though much has been done, more still remains to be effected for the distinct knowledge of the laws and relations of these mysterious phenomena.

That wonderful property by which a certain ore or stone attracted iron, seems to have been known from the most remote antiquity. The magnet was called by Aristotle, κατ' ἐξοχην "ἡ λιθος," and its name has been by some derived from the supposed discoverer, by others from the town or city in Asia where it was said to be discovered. Various Greek and Roman philosophers have described its attractive powers; and Pliny, amongst others, in his usually

animated manner, in speaking of its attraction for iron, says, "Domitrixque illa rerum omnium materia ad inane nescio quid curret;" but its directive force, and consequently its use in navigation, was wholly unknown to the ancients.

We are uncertain when the polarity of the magnet was first applied to maritime purposes in Europe. The period is some time between 1100 and 1300.

By some of the ancient authors the discovery is referred to Flavio Gioia, a native of Amalfi, in the kingdom of Naples, in 1300; by others it is said to have been brought from the Indies, by Marco Polo, in 1240. The Chinese indeed pretend to have made the discovery some ages before it was known to the Europeans; but the natural vanity of this people renders it impossible to depend upon any statement not connected with authentic historical documents.

That the compass did not point due north, (or its variation,) was discovered some time about the end of the 15th century, probably in the two great voyages to the eastern and western worlds, by Vasco de Gama and Christopher Columbus. The son of Columbus claimed the merit of this discovery for his father, in 1495. By other writers, it is given to Sebastian Cabot, then in the employment of Henry VII. of England.

With respect to the change in the variation in the same place, and the knowledge of the dip of the needle, there is no such defect of historical precision; both the dates and

the discoverers are well known. The dip was ascertained by Robert Norman, our countryman, in London in 1581, and the change of variation was accurately demonstrated by Professor Gellibrand of Gresham College, in 1635.

As the most important circumstances relating to the polar or directive force of magnetic bodies, were brought forward in this country, so likewise were the first just theoretical views respecting the circumstances of its communication and action. These views are owing to Dr. Gilbert of Colchester, who published his Latin treatise, *De Magnete*, in 1600.

In this truly philosophical and original work, the author endeavours to prove that the phenomena of magnetism are owing to the magnetic polarity of the earth; that soft iron becomes a temporary magnet by the influence of the earth; that in steel the magnetic property is induced by the same cause with more difficulty, but that it is permanent; and he explains the motion of the needle, and the power of common magnets, by showing that opposite poles of different magnets attract each other in some definite ratio of their distance. He indulges, which could hardly be avoided in that age, in some vague hypotheses, and details some futile experiments; but notwithstanding this, his views display very extraordinary powers of mind; and though censured by his contemporary Lord Bacon, for endeavouring to solve the phenomena of gravitation by magnetic attraction, yet his

researches have a character of inductive reasoning, perfectly in the spirit of the philosophy of that great man, who, had he studied his work with more attention, would have found in it numerous examples of his own sublime method of pursuing science—a contempt for the speculative authority of the ancients, and an appeal, almost new in that time, to the laborious method of repeated experiments.

The general views of Gilbert were established, and his particular errors corrected by the early philosophers of this Society, by Wallis, Hooke, Halley, and Brooke Taylor.

The diurnal variation of the needle was discovered by George Graham, in 1722; and the same ingenious artist first applied the vibrations of the needle as a measure of magnetic intensity.

That magnetic attractions and repulsions follow the law of the square of the distance, has been regarded as nearly demonstrated by the experiments of Lambert, Coulomb, and Robinson; and mathematical views of the theory of magnetism, upon the hypothesis of a single magnetic fluid, have been brought forward by Epinus and Robinson; and the highest refinements and precision of the analytical method have been applied on the supposition of two fluids—the austral and the boreal, in two very recent Memoirs of M. Poisson, presented to the Royal Academy of Sciences at Paris.

The hypothesis of magnetic, which so closely agrees with

that of electric fluids, has been defended by similar arguments, and illustrated by analogous experiments; and the connexion between the two classes of phenomena, had been often observed and dwelt upon by philosophers. Beccaria had, indeed, from the magnetic effects produced by lightning, endeavoured to solve the magnetism of the earth by supposing it produced by electrical currents, which were likewise the cause of the Aurora Borealis and Australis. But these, and other opinions of the same kind, were supported only by vague analogies and insufficient facts, and, till the discovery of M. Oersted, the true relations of magnetism and electricity were unknown.

I could with pleasure dwell on this discovery and the immediate consequences of it in the developement of new and extraordinary results, and would the time allotted to a discourse of this nature allow, I should have great satisfaction in describing to you the labours and the discoveries of various philosophers belonging to this and other learned Societies of Europe, and which have established, within the last five years, a perfectly new order of facts; not less brilliant from their striking and unexpected results, than important in their relations and theoretical applications to other phenomena of nature. I cannot, however, quit this part of my subject without calling your attention to the manner in which these discoveries have originated and been pursued,

as it offers the most remarkable instance upon record of the unity of the laws of nature—of the manner in which remote phenomena are connected together, and the happy consequence of due attention to unexpected or uncommon results.

A fact discovered by Galvani, and by him believed to be strictly physiological, investigated by the genius of Volta, was the origin of his wonderful pile or battery ; and this instrument, after its powers had been apparently exhausted in demonstrating new laws in electricity, and affording us new creations in chemistry,—altering our arrangements and systems, became, in the hands of the Danish philosopher, a source of novel and unexpected combinations, throwing a light upon part of the corpuscular philosophy which were before in absolute darkness.

Though the labours of M. Arago, which have been the object of the vote of your Council, cannot be considered as immediate consequences of M. Oersted's discovery, yet it is probable that they never would have been undertaken had not this discovery immediately excited the attention of their excellent author, who was amongst the first philosophers that endeavoured to investigate, compare, and illustrate the facts of electro-magnetism.

Coulomb imagined that all substances in nature were susceptible of magnetic attractions ; but from the nature of the

bodies in which he supposed he had discovered these powers, it appeared probable that his results were owing to small quantities of iron in the materials used.

When it was found that magnetism was always a consequence of electrical action, various experiments were made with hopes of producing magnetic effects in other metallic bodies besides those in which they have long been recognised; but it was found, with other metals, that all magnetic effect in electrical experiments were transient, disappearing with the electrical cause.

Till M. Arago's inquiries, iron, nickel, and cobalt, and their combinations, were the only species of matter apparently affected by magnets. His experiments extend this property, under certain modifications, to all metallic substances, and it is said, though we have as yet no distinct details, to water, and various other bodies.

M. Arago found that the extent of the vibrations of a magnetized needle, or the spaces through which it moved, were greatly diminished by holding over it a plate of copper; and by causing a plate of copper to revolve below it, the direction of the needle was soon changed; it began to turn round, and the velocity of its revolutions increased, till at last they became so quick as to be incapable of being numbered. M. Arago made the same trials with other metallic substances and with similar results, differing, as might be expected, in intensity; and his experiments have been success-

fully repeated by Messrs. Herschel and Babbage, and by Mr. Christie of Woolwich. Messrs. Herschel and Babbage have not only confirmed, but extended and illustrated them by new inquiries. As action and re-action must in all cases be equal, it occurred to them to set in motion metallic plates by magnets, and they have been perfectly successful. A powerful horse-shoe magnet, made to revolve beneath metallic plates, sets them in motion, and gives them a great velocity of revolution. In these experiments, which I have had the satisfaction of witnessing, not only zinc, lead, tin, bismuth, and antimony have been used, but likewise mercury and carbon, in that state in which it is found in the retorts at gas manufactories, and with similar results, though differing considerably in degree. MM. Herschel and Babbage, in a paper printed in the last part of the *Transactions*, have developed their researches and views in a very masterly manner; and those who wish to enter into this new field of science, cannot do better than study their experiments and their reasoning.

It is for the discovery of this fact,—the power of various bodies, principally metallic, to receive magnetic impressions, in the same, though in a more evanescent manner than malleable iron, and in an infinitely less intense degree,—that your Council have awarded your medal; and you, I am sure, cannot but approve of their decision, for whether in its immediate relations or ultimate applications, there is no phy-

sical fact which has been made known, during the present year, that can, with propriety, be put in competition with it.

By extending the empire of magnetism to a number of bodies, it removes much of what was mysterious and inexplicable in that department of science, and renders it a branch of the general philosophy of nature; and when the new analogies between magnetic and electrical action, established by these phenomena, are considered, there is much reason to hope that they may be ultimately referred to the same cause with chemical affinity, and possibly be found identical with the general quality or power of attraction of gravitation.

Mr. Barlow has published several papers in the *Transactions of the Royal Society*, which have established his character, both as a judicious and accurate experimenter and able reasoner. These papers are, 1. On the Effects produced on the Rates of Chronometers by the Proximity of Masses of Iron. 2. On the Diurnal Variations of Magnetized Needles under a reduced Directive Power. 3. On the Anomalous Magnetic Action of Ignited Iron at different Temperatures. 4. On the temporary Magnetic Effects produced in Iron by its Rotation. And he has likewise given to the world a treatise, in which he has endeavoured to explain the phenomena of magnetism by mathematical principles, according to an hypothesis, the same in its ground-

work as that of the French philosophers, and in which the circumstances of the connexion of magnetic powers with surface is demonstrated, and the whole subject treated with great ability and profound knowledge.

The curious facts brought forward by Mr. Barlow, and the general accuracy of his reasoning, and the spirit of induction in his researches, would undoubtedly have claimed the attention of your Council, and might have led them to balance his merits with those of other contributors to your *Transactions;* but their opinion was fixed, and their decision formed by a practical application of science, of great ingenuity and considerable utility.

All persons, who have attended at all to the phenomena of magnetism since the time of Gilbert, know that masses of iron become magnetic by the action of the earth; a bar of soft iron, for instance, held vertically, has its north pole uppermost, and attracts the needle in the same manner as the pole of the earth; and any quantities or masses of iron, following the same law, exert an action on the needle proportional to the square of the distance, and of course destroy or diminish, in a certain ratio, the action of the north pole of the earth. It is extraordinary that so important a circumstance as the action of the iron in a ship on the needle, had not earlier and more strongly arrested the attention of navigators. Even Dr. Halley, the most accomplished and profound philosopher that ever made long voyages, though he

observed the effect, does not seem to have thought it worthy of correction, and that, when making a set of minute observations on variations, he says, in his paper in the *Transactions*, "We know by experience how little the iron guns on board a ship affect the needle." This, however, probably arose from the circumstance, that he was never in very high latitudes. Mr. Wales, the astronomer in Captain Cook's voyage, seems to have observed the fact, but Walker, in his *Treatise on Magnetism*, was the first person who called the attention of nautical men to the circumstance. Captain Flinders brought it before the notice of the Admiralty, and Mr. Bain pointed out the fatal consequences attending it as a source of error in reckoning; and lately the Arctic Expeditions have given the fairest and fullest opportunity of determining the circumstance, as may be learnt in the narrations of Captains Ross, Sabine, Parry, Lyon, and other able officers; and some correct general views on the subject have been brought forward by M. Lecount.

Mr. Barlow, after making a number of experiments on the phenomena presented by different large masses of iron, and recurring to the principle, that the contiguity of a small mass, makes it equal or superior in power to larger masses, and that the attractions and repulsions diminish as the square of the distance, thought of two methods of correcting the errors arising from the magnetism of the iron in ships; one by compensating, the other by doubling them, by means

of small masses, or thin plates of iron, placed near the compass, and the relation of which to the magnetism of the earth, the iron in the ship, and the needle, should be determined by experiments.

The last method he has adopted in practice; and though, as M. Poisson has shown, it cannot be considered strictly and mathematically precise, yet it may be regarded as sufficiently exact for all common purposes of navigation, and its utility has already been proved by the observations of Captain Baldey, Captain Sabine, Captain Parry, Lieutenant Mudge, Lieutenant Foster, and various other able and enlightened officers.

The Royal Society has always, since its first establishment, given particular encouragement, and particular attention, to those departments of science which are strictly practical, and which offer the best vindication and the highest praise of the experimental and inductive method, bringing philosophy, as it were, from the heavens to the earth, and fixing her abode, not in visionary, splendid, and airy edifices, but amongst the resting-places and habitations of man. To point out a useful application of any doctrine or discovery, has always been their highest pride, and fortunately they have had many noble opportunities and examples; indeed, there is scarcely any instance of a considerable advance made in the knowledge of nature, without being soon connected with some tangible benefit or advantage, as light is almost always

accompanied by heat, the illuminating by the productive and nourishing principle.

In conformity to the usages and feelings of the Society, the Council has awarded the medal to Mr. Barlow, who, by reasoning and experimenting upon a few simple facts, long known but never applied, has founded a useful invention, tending to the perfection of an instrument the most important, perhaps, to Britons, of all those which have been the result of scientific principles, increasing the perfection of an art which is not only one of the greatest sources of our power, but a bond of union amongst nations, securing their intercourse, and extending the progress of commerce, civilization, and refinement.

Mr. South,

In transmitting this medal to M. Arago, assure him of the interest we take in his ingenious and important researches; and inform him that we wait with impatience for the continuation of his labours on this new and fertile subject. As one of our Fellows, his discoveries have the same interest for us that they have for his brethren of the Royal Academy of Sciences, which, for more than a century and a half, has gone on encouraging and emulating our labours. You and our worthy secretary* are recent examples of

* Mr. Herschel.

liberality on their part, and of the respect paid to British talent; we, I trust, shall never be behind them in dignity and nobleness of sentiment: far be from us that narrow policy which would contract the minds of individuals and injure the interest of nations, by cold and exclusive selfishness; which would raise the greatness of one people by lowering the standard of that of another. As in commerce, so in science, no country can become worthily pre-eminent, except in profiting by the wants, resources, and wealth of its neighbours. Every new discovery may be considered as a new species of manufacture, awaking novel industry and sagacity, and employing, as it were, new capital of mind. When Newton developed the system of the universe, and established his own glory and that of his country on imperishable foundations, he might be regarded as giving a boon to the civilized world for which no adequate compensation could ever be made; yet, even in this the most difficult and sublime field of discovery, Britain has been paid, if not fully, yet fairly, by the labours of Euler, La Grange, and, above all, Laplace; perfecting the theory of the lunar motions and planetary perturbations, and affording data of infinite importance in the theory and practice of navigation. Fortunately science, like that nature to which it belongs, is neither limited by time nor by space. It belongs to the world, and is of no country and no age. The more we know, the more we feel our ignorance, the more we feel how much

remains unknown; and in philosophy, the sentiment of the Macedonian hero can never apply,—there are always new worlds to conquer.

Mr. Barlow,

I have great pleasure in presenting you with this medal, in the name of the Royal Society. Receive it as the highest mark of distinction which they have it in their power to bestow. You have already received marks of approbation, both at home and abroad, far more valuable in a pecuniary point of view, but no one which I think ought to give you more durable satisfaction, for this reward has, I believe, never been made, except after dispassionate and candid discussion; never to gratify private feelings, or to call for popular applause; and amongst the philosophers who have received it, are names of the very highest rank in science. We trust, both on account of the public good and your own glory, that you will engage in, and accomplish, many new labours; you have had not merely scientific success, but one still more gratifying to your heart and feelings, the idea that you have been useful to your country, and secured the gratitude of a body of men who are not tardy in acknowledging benefits.

DISCOURSE OF THE PRESIDENT,

ANNIVERSARY, 1826.

CHARACTERS OF

TAYLOR COMBE, Esq., AND Sir Thomas STAMFORD RAFFLES.

AWARD OF THE ROYAL MEDALS TO

Mr. JOHN DALTON, F.R.S.,

FOR HIS DEVELOPEMENT OF THE THEORY OF DEFINITE PROPORTIONS, USUALLY CALLED THE ATOMIC THEORY OF CHEMISTRY;

AND TO

JAMES IVORY, Esq., F.R.S.,

FOR HIS VARIOUS MATHEMATICAL PAPERS, PUBLISHED IN THE PHILOSOPHICAL TRANSACTIONS.

AND ON THE AWARD OF THE COPLEY MEDAL TO

JAMES SOUTH, Esq., F.R.S.,

FOR HIS OBSERVATIONS ON DOUBLE STARS.

GENERAL VIEWS ON THE SCIENTIFIC HISTORY AND PARTICULAR MERITS OF THE SUBJECTS FOR WHICH THE PRIZES WERE GIVEN.

I CANNOT pass over two of the names in this list without an expression of sorrow, at the loss the Society and the public have sustained in their death. TAYLOR COMBE, Esquire, for many years one of your secretaries, was distinguished as a learned antiquarian, an elegant and accomplished classical scholar, and an excellent judge of works of art. In his official situation in your service, he attended with great care and accuracy to the publication of the *Transactions*, till the state of his health interfered with his business and pursuits. In his public situation in the British Museum, he was most easy of access, and accommodating in promoting the pursuits of artists and scholars. His loss will be severely felt in the sister Society of Antiquarians, and lamented by all who were acquainted with the genuine worth of his character, the good nature and candour of his mind, and the kindness and simplicity of his manners.

Sir T. STAMFORD RAFFLES was not a contributor to your *Transactions* directly; yet he was the occasion of many disco-

veries in zoology, botany, and physiology. His disinterested promotion of every branch of natural history; his sacrifice of his fortune and his time to collections in this department of knowledge; the readiness with which he laid them open to scientific men, claimed the highest admiration. Occupying high situations in our Empire in the East, he employed his talents and his extensive researches, not in the exercise of power or the accumulation of wealth, but in endeavouring to benefit and to improve the condition of the natives, to found liberal institutions, and to establish a permanent commercial intercourse between the colonies where he presided, and the mother country, which, whilst it brought new treasures to Europe, tended to civilize and to improve the condition of the inhabitants of some of the most important islands of the East. Neither misfortune nor pecuniary losses damped the ardour of his mind in the pursuit of knowledge, Having lost one splendid collection by fire, he instantly commenced the formation of another; and having brought this to Europe, he made it not private, but public property, and placed it entirely at the disposition of a new Association, for the promotion of zoology, of which he had been chosen President by acclamation. Many of the Fellows of this Society can bear testimony to his enlightened understanding, acute judgment, and accurate and multifarious information; and all of them must, I am sure, regret the pre-

mature loss of a man who had done so much, and from whom so much more was to be expected, and who was so truly estimable in all the relations of life.

On our foreign lists of deaths, there is only one name.

Padre Joseph Piazzi, formerly of Palermo, and late of Naples, whose name will descend to posterity, connected with one of the most important discoveries of the age, that of the planet Ceres; and who, for nearly half a century, had pursued his favourite science with great ardour and success. He died, according to the course of nature, in old age, having enjoyed a glory, which in no respect disturbed his repose.

Royal Medals.

You will recollect, Gentlemen, that the Right Honourable the Secretary of State for the Home Department, who, I am happy to state, has, upon all occasions, shown his zeal to promote the interests of science, and of the Royal Society, announced at your Anniversary dinner, last year, his Majesty's gracious intention of founding two annual prizes, each of the value of fifty guineas, to be at the disposal of the President and Council of the Royal Society, for promoting the objects and progress of science, by awakening honourable competition amongst philosophers.

As this foundation was announced in the true spirit of royal munificence, so it has been completed with an exalted liberality, worthy of our august patron. The two prizes are established in the forms of silver and gold medals, to be given for important discoveries or useful labours in any department of science; and they are laid open to learned and ingenious men of all countries, without any principle of narrow policy or national exclusion.

In the first award of these royal medals, your Council have had some difficulties in their decision. Discoveries are sometimes made of great interest, which require time and new labours for their confirmation; and when their importance is great and their bearings extensive, years even may pass away, before a full conviction of their truth can be obtained. Now, though within the year just past, there have been more than one important discovery announced to the world, yet there are none which can be said to be, as yet, fairly and securely established.

Your Council, therefore, have rather looked to labours which have been sanctioned by time, the importance of which is generally felt, though not sufficiently acknowledged; which may be said to have acquired their full authority only within a very short period, and which, consequently, may be considered as within the literal meaning of the foundation.

I trust you will approve of the principle of the decision,

and of the manner in which it has been made by your Council.

They have awarded the first prize to Mr. JOHN DALTON, of Manchester, Fellow of this Society, for the Developement of the Chemical Theory of Definite Proportions, usually called the Atomic Theory, and for his various other labours and discoveries, in physical and chemical science.

What Mr. Dalton's merits are, I shall briefly endeavour to state to you, though it is impossible to do justice to them in the time necessarily allotted to this address.

The brilliant and important discoveries of Black, Cavendish, Priestley, and Scheele, had added to chemistry a great variety of substances before unknown, many of which had forms never before witnessed in the material world; and the new and accurate logic of Lavoisier had assigned to many of them their just places in the arrangements of chemistry, and had established the characters of most of them, as simple or compound bodies. Novel uses of these substances were ascertained, new combinations of them made, and their applications to the purposes of common life constantly extended by various distinguished chemists, in the close of the last century; but with respect to the weight or quantity, in which the different elementary substances entered into union to form compounds, there were scarcely any distinct or accurate data. Persons whose names had high authority, dif-

fered considerably in their statements of results, and statical chemistry, as it was taught in 1799, was obscure, vague, and indefinite, not meriting even the name of a science.

To Mr. Dalton belongs the distinction of first unequivocally calling the attention of philosophers to this important subject. Finding, that in certain compounds of gaseous bodies the same elements always combined in the same proportion; and that when there was more than one combination, the quantity of the elements always had a constant relation, such as 1 to 2 or 1 to 3 or to 4. He explained this fact on the Newtonian doctrine of indivisible atoms, and contended, that the relative weight of one atom to that of any other atom being known, its proportions or weight, in all its combinations, might be ascertained; thus making the statics of chemistry depend upon simple questions, in subtraction or multiplication, and enabling the student to deduce an immense number of facts, from a few well authenticated, accurate, experimental results.

I have said, that to Mr. Dalton belongs the distinction of first unequivocally calling the attention of philosophers to this subject; but I should be guilty of historical injustice, if I did not state, that various opinions and loose notions on the same mode of viewing the combinations of bodies had existed before. And not to go back to the time of the Greek schools, to the Homoids of Anaxagoras, or to the Atoms of Epicurus, nor to those Newtonian philosophers who supported

the permanency of atoms, and their uniform combinations, such as Keil, Friend, Hartley, and Marzucchi; there may be found in the works of Dr. Bryan Higgins, Mr. William Higgins, and Professor Richter, hints or conclusions, bearing decidedly on this doctrine. Dr. Bryan Higgins, in his Experiments and Observations, relating to acetous acid, fixable air, dense, inflammable air, fire, and light, published in 1786. contends, that elastic fluids unite with each other in limited proportions only; and that this depends upon the combination of their particles or atoms with the matter of fire which surrounds them as an atmosphere, and makes them repulsive of each other; and he distinguishes between simple elastic fluids, as composed of particles of the same kind, and compound elastic fluids, as consisting of two or more particles combined, in what he calls molecules, definite in quantity themselves, and surrounded by definite proportions of heat. Dr. Bryan Higgins's notions have, I believe, never been referred to by any of the writers on the Atomic Theory. Mr. William Higgins's claims have, on the contrary, often been brought forward. Yet, when it is recollected, that this gentleman was a pupil and relation of Dr. Bryan Higgins, and that his work, called the *Comparative View*, was published some years after the treatises I have just quoted, and that his notions are almost identical (with the addition of this circumstance, that he mentions certain elastic fluids, such as the compounds of azote, consisting of

1, 2, 3, 4, and 5 particles of oxygen, to one of azote), it is difficult not to allow the merits of prior conception, as well as of very ingenious illustration, to the elder writer.

Neither of the Higgins attempted to express the quantities in which bodies combine by numbers, but Richter has a claim of this kind. In his *New Foundations of Chemistry*, published in 1795, he has shewn, that when neutrosaline bodies in general undergo mutual decomposition, there is no excess of alkali, earth, or acid: and he concludes, that these bodies are invariable in their relation to quantity, and that they may be expressed by numbers.

Mr. Dalton, as far as can be ascertained, was not acquainted with any of these publications, at least he never refers to them: and who ever will consider the ingenious and independent turn of his mind, and the original tone prevailing in all his views and speculations, will hardly accuse him of wilful plagiarism. But let the merit of discovery be bestowed wherever it is due; and Mr. Dalton will be still pre-eminent in the history of the theory of definite proportions. He first laid down clearly and numerically, the doctrine of multiples, and endeavoured to express by simple numbers, the weights of the bodies believed to be elementary. His first views, from their boldness and peculiarity, met with but little attention; but they were discussed and supported by Drs. Thomson and Wollaston; and the table of chemical equivalents of this last gentleman separates the

practical part of the doctrine from the atomic or hypothetical part, and is worthy of the profound views and philosophical acumen and accuracy of the celebrated author.

Gay-Lussac, Berzelius, Dr. Prout, and other chemists, have added to the evidence in favour of the essential part of Mr. Dalton's doctrine; and for the last ten years, it has acquired almost every month, additional weight and solidity.

Gentlemen, I hope you will clearly understand that I am speaking of the fundamental principle, and not of the details as they are found in Mr. Dalton's system of chemical philosophy. In many of these the opinion of the composition of bodies is erroneous, and the numbers gained from first and rude experiments incorrect; and they are given with much more precision in later authors on chemistry. It is in the nature of physical science, that its methods offer only approximations to truth; and the first and most glorious inventors are often left behind by very inferior minds, in the minutiæ of manipulation; and their errors enable others to discover truth.

Mr. Dalton's permanent reputation will rest upon his having discovered a simple principle, universally applicable to the facts of chemistry—in fixing the proportions in which bodies combine, and thus laying the foundation for future labours, respecting the sublime and transcendental parts of the science of corpuscular motion. His merits in this respect

resemble those of Kepler in astronomy. The causes of chemical change are as yet unknown, and the laws by which they are governed; but in their connexion with electrical and magnetic phenomena, there is a gleam of light pointing to a new dawn in science; and may we not hope, that in another century chemistry having, as it were, passed under the dominion of the mathematical sciences, may find some happy genius, similar in intellectual powers to the highest and immortal ornament of this Society, capable of unfolding its wonderful and mysterious laws.

I could with pleasure enter into a history of Mr. Dalton's other labours in chemical and physical science, but it would be impossible to give even an intelligible sketch of them, without occupying too much of the time which ought to be allotted to the other business of this day. His experiments on the equal expansion of elastic fluids by heat, are allowed to be accurate, and their results well founded. His notions on the nature of the atmosphere, the mixture of gaseous bodies, and the distribution and communication of heat, and on the magnetic phenomena, display the resources of an ingenious and original mind; and his essays on evaporation and the force of vapour, and the tests for discovering water in air have offered important practical applications; but still their interest, though of a high kind, is inferior to that of the doctrine of definite proportions.

I trust you will allow the justice of the decision of your Council, which has claimed for our countryman this first testimony of royal benevolence to science.

There is another motive which influenced them, and which I am sure will command your sympathy. Mr. Dalton has been labouring, for more than a quarter of a century, with the most disinterested views. With the greatest modesty and simplicity of character he has remained in the obscurity of the country, neither asking for approbation or offering himself as an object of applause. He is but lately become a Fellow of this Society, and the only communication he has given to you is one, compared with his other works, of comparatively small interest; their feeling on the subject is therefore pure. I am sure he will be gratified by this mark of your approbation of his long and painful labours. It will give a lustre to his character which it fully deserves; it will anticipate that opinion which posterity must form of his discoveries; and it may make his example more exciting to others, in their search after useful knowledge and true glory.

Your Council have awarded the second binary medal on the royal foundation, to JAMES IVORY, M.A., for his papers on the Laws regulating the Forms of the Planets, on Astronomical Refractions, and on other Mathematical Illustrations of important Parts of Astronomy.

Every one who considers the glory derived to the Royal Society and to this nation, by the invention of the fluxional or differential calculus, and its application to the laws of the system of the universe,—every one who remembers the ascendency which for more than fifty years this Society enjoyed in the most sublime department of science, and the honour that would result from recovering it, will, I am sure, be pleased with this decision of your Council, the object of which is, not only to reward a highly distinguished individual, but likewise by setting forth his example, if possible to encourage others to pursue the same honourable career.

All Mr. Ivory's most important mathematical labours have been communicated to the Royal Society, and published in your *Transactions*.

These communications are seven in number. Five, including the first paper given in to the Society in 1809, and the last published in 1825, are on the Forms which Spheroidal Bodies must assume, revolving on their Axes, and acted on by the known Laws of Gravity and the Centrifugal Force. Of the two others—one is on a new Method of deducing the Approximation to the Orbit of a Comet, and the other of the Astronomical Refractions.

One of the most important problems which exercised the skill of the illustrious author of the *Principia*, was the effect of gravity and the centrifugal force in giving a peculiar form to a fluid mass; which he calculated would

correspond to the figures of the earth and the other planets. Maclaurin elucidated Newton's idea by a very refined and elegant synthetical process of reasoning. He determined generally the attractive forces of a homogeneous spheroid of revolution on a point placed within the solid or in its surface; but there were still difficulties left, when the attracted point is placed without the solid, which were solved by the ingenuity of Legendre. The Marquis de la Place, in his *Mechanique Celeste*, took a more enlarged view of the problem, and extended his method to all elliptical spheroids; but notwithstanding the refined principles and profound investigations of this illustrious geometer, and the elucidations of them attempted by his friend and rival La Grange, there were some points unsolved, remaining in the application of the formulæ and the generalization of the theorems, which awakened Mr. Ivory's attention, and which led him to examine the whole subject anew. In his first paper he considers the ellipsoid as homogeneous, and treats the problem by the method of three co-ordinates. In his second and third papers he examines with great minuteness the methods of M. de la Place, and M. de la Grange. In his fourth paper he extends his own method to all such spheroids as have their radii expressed by rational and integral fractions of three rectangular co-ordinates of a point in the surface of a sphere. And in the fifth he solves the problem in its generality, considering the body as a fluid homogeneous

ellipsoid of revolution. I cannot pretend to give any idea of the mathematical resources displayed in these problems, and which even the most accomplished geometer could not render intelligible by words alone; but I can speak of the testimony given by M. de la Place himself in their favour. That illustrious person, in a conversation which I had with him some time ago, on Mr. Ivory's first four communications, spoke in the highest terms of the manner in which he had treated his subject; one he said of the greatest delicacy and difficulty, requiring no ordinary share of profound mathematical knowledge, and no common degree of industry and sagacity in the application of it.

Comets, before the foundation of this Society, were considered rather as objects of superstitious awe and vulgar astonishment, to be feared as portents, or admired as wonders, than regarded as celestial phenomena, having a regular place and order in the solar system. The uncertainty of their appearances, their changes in brightness, the alterations in their most remarkable feature, the coma or tail, the rapidity and irregularity of their motions, sometimes nearly rectilineal, sometimes greatly curved, and sometimes retrograde, prevented even the most distinguished early astronomers, including Kepler, from forming any just opinions respecting their nature or their motions: and it was reserved for the unrivalled sagacity of Newton to show that they belonged to the same system, and were governed by the same laws as

the planetary bodies, moving like them in conic sections but in different curves, depending upon the proportion of rectilineal velocity to the quantity of deflection by gravitation towards the sun.

The triumph of the Newtonian views of the cometary system was considered as completed by the return of the comet predicted by Halley in 1759; but still great difficulties existed in laying down any general methods for calculating their times of return and places—from the circumstance of the earth and comet being both in motion—from the uncertain nature of the curve, and the disturbing causes which may act unknown to the observer, in space. Such celebrated men as Boscovich, Legendre, Lambert, Laplace, and Gauss, have all contended with these difficulties with a success more or less partial. Notwithstanding the authority of such names, Mr. Ivory has not feared to enter into the same field of investigation, and he conceives that, considering the orbit of a comet as parabolic, three geocentric observations of its place are sufficient to furnish, by the method which he has proposed, elements for determining its course nearer the true ones, than they have been generally supposed, and a good first approximation to the solution of a problem, which in some of its conditions must be indeterminate.

I shall say a few words only of Mr. Ivory's paper on the Astronomical Refractions.

The ancient astronomers had observed that there was a difference between the real and apparent places of the stars, arising from the refraction of light in passing through the atmosphere. Tyche Brahè by rude methods sought to free his observations from the effect of this irregularity; and the problem has occupied the attention of Cassini, Kramp, La Place, Bessel, and Brinkley.

A ray of light from a star, in passing through the atmosphere to the surface of the earth, is bent from its rectilineal course, by an attraction which depends principally on the density of the air, resulting from pressure and temperature.

If the atmosphere had consisted only of a single elastic fluid, the temperature and pressure of which diminished according to a regular and uniform ratio from the surface of the earth, the problem of refractions would be an exceedingly simple one; but unfortunately there are many causes which as yet are only imperfectly understood, that make the conditions much more complicated—the radiation of heat from the earth, the deposition of water, and the uncertainty whether the upper regions of the atmosphere are similar in composition to the lower ones.

Mr. Ivory's investigation is a very refined one. He has considered most of the uncertainties and all the difficulties of the subject; and if it is still left in an unfinished state, in making the corrections for stars near the horizon, it is not owing to any want of mathematical skill or acuteness

of logic in this profound author ; but to the imperfection of our physical experiments which must furnish the data in all operations of this kind.

Whoever considers the fluctuations of the barometer, thermometer, and hygrometer in this climate at this season, and the different effects of radiation or cooling causes in the nights, will have an idea of the difficulty of the subject, and the impossibility, it may be so called, with the present tables of determining the true place of a star, within the limits of these changes.

Your Council of this year, as you know, Gentlemen, contains several distinguished mathematicians, who were decisive in claiming this award for Mr. Ivory, and I trust your approbation will sanction their decision. I may likewise apply to Mr. Ivory praise of the same kind as that which I had the honour of applying to Mr. Dalton. He has pursued science with the same disinterested zeal, and as it were, with a pure affection for the cause of truth. He has received no emoluments, and occupied no places of dignity. He has quietly and unobtrusively brought forward his labours—they have had no popular object, and only a high scientific aim ; being intelligible only to a few superior minds, and he has waited for the slow progress of time to ensure him their confidence and approbation.

I feel the highest satisfaction in anticipating that this

award may renovate the activity of the Society upon this department of science, and that it will return, "veteris vestigia flammæ," with new ardour to its so long-neglected fields of glory.

Whether we consider the nature of mathematical science or its results, it appears equally amongst the noblest objects of human pursuit and ambition. Arising a work of intellectual creation, from a few self-evident propositions on the nature of magnitudes and numbers, it is gradually formed into an instrument of pure reason of the most refined kind, applying to and illustrating all the phenomena of nature and art, and embracing the whole system of the visible universe: and the same calculus measures and points out the application of labour, whether by animals or machines—determines the force of vapour, and confines the power of the most explosive agents in the steam engine—regulates the forms of structures best fitted to move through the waves—ascertains the strength of the chain-bridge necessary to pass across arms of the ocean—fixes the principles of permanent foundations in the most rapid torrents—and leaving the earth filled with monuments of its power, ascends to the stars, measures and weighs the sun and the planets, and determines the laws of their motions, and even brings under its dominion those cometary masses that are, as it were, strangers to us wanderers in the immensity of space; and applies

data gained from the contemplation of the sidereal heavens to measure and establish time and movement, and magnitudes below.

Copley Medal.

There is another annual medal, Gentlemen, on which I have to announce to you the decision of your Council, that founded on the donation of Sir Godfrey Copley, Bart. This, for a long while, was the only mark of distinction which you had to bestow: and when the illustrious names to whom it has done honour are considered, and the great and extraordinary advances in natural knowledge with which the award has been connected, it will, I trust, continue to retain all its dignity, as a mark of our respect, and all its importance as a pure honorary reward. It has been voted this year to James South, Esq., Fellow of the Royal Society, for his paper of Observations of the Apparent Distances and Positions of four hundred and fifty-eight double and triple Stars, published in the present volume of the *Transactions*.

The illustrious Florentine philosopher to whom we owe the discovery of the telescope, and all the *first* pure experimental results in natural philosophy, was, as I mentioned in a former discourse, the author of the idea of attempting the discovery of the parallax of the fixed stars by the observation of double stars. Gallilæo supposing the fixed stars to

be analogous to our sun in nature and magnitude, but at immense distances from us, and from each other, proposed the observation of two stars of different apparent sizes, and seemingly very near each other, at the summer and winter solstice, giving the two extremities of the earth's orbit, with the hope that a difference might be observed in their position, indicating parallax.

This method was insisted on by Dr. Wallis, but not put in practice, as the questions respecting the discoveries of Newton soon occupied, almost exclusively, the attention of philosophers.

Dr. Bradley and Mr. Molyneux, in endeavouring to follow the observations of Hooke to determine the parallax of fixed stars near the zenith, by an instrument constructed by Mr. George Graham, and more accurate than had ever before been made, believed they observed a proper and considerable motion of γ Draconis: and Dr. Bradley, after Mr. Molyneux's death, pursuing the same inquiries from 1727 to 1748, was convinced of an apparent motion of this, and of other fixed stars.

The Rev. Mr. Michell, in a very ingenious and elaborate paper published in the *Philosophical Transactions* for 1767, developes some new and very ingenious views of the sidereal system. He supposes that stars may be arranged in groups; and to whatever cause this may be owing, whether to their mutual gravitation, or to some other law or appoint-

ment of the Creator, he supposes that some of them may act to others the parts of secondary to primary planets, or of planets to the sun.

Fortunately for astronomy Sir William Herschel took up this subject in 1779, principally with the hope of discovering parallax; but though he failed in this object, yet his observations led to new and most important discoveries, confirming and extending the ideas of Mr. Michell, and advancing, in a most extraordinary manner, our knowledge of the system of the universe.

The results of Sir William Herschel's observations from 1779 to 1784, were published in two catalogues in the *Philosophical Transactions* for 1782 and 1785, and consist of descriptions and measures of seven hundred and two double and triple stars. The labour of re-examination was undertaken and executed by him in 1801, 1802, 1803, and 1804, after a lapse of twenty years, and the changes observed or suspected, were recorded in two other papers published in the volumes of the Society for 1802 and 1804. In 1816 a second examination of the measures was commenced by Mr. Herschel, a son worthy of his father, and some progress made in it; and Mr. South being in possession of certain instruments, perfected by the labour and skill of Mr. Troughton, became associated with Mr. Herschel in these researches, which were recommenced in March, 1821, and carried on by Mr. Herschel and Mr. South jointly till

1824, and their results published in an extensive memoir, containing their observations of three hundred and eighty double or triple stars in the *Transactions* of that year.

By these observations many of the conclusions and suspicions of Sir William Herschel were proved, the existence of binary systems in which two stars appear to perform to each other the office of sun and planet was distinctly shown, and the periods of rotation of more than one such pair determined in a manner approaching to exactness; the immersions and emersions of stars behind each other were demonstrated, and real motions amongst them detected, rapid enough to become sensible and measurable in very short intervals of time.

These important researches were continued by Mr. South, at Blackman Street, and at Passy, near Paris, in 1823, 1824, and 1825, and their results form the first part of the *Philosophical Transactions* for this year. The work which, as I have already mentioned, is the object of the award of your Council.

These laborious and accurate observations which fill three hundred and ninety-one pages, relate to four hundred and fifty-eight double and triple stars: of these one hundred and twenty-three were discovered and observed by Sir William Herschel, one hundred and sixty were discovered by Mr. South, at Passy, and the remaining one hundred and seventy-five by other astronomers.

There are some very curious, I may say, almost wonderful, instances of proper motions of stars, of occultations of stars by each other, proved in these pages; but the most important result is, the apparent connexion of stars in binary systems of rotation, which seems to render it probable that the law of gravitation extends to this part of the universe. There are forty-three phenomena of this kind observed by Mr. South: in some the matter is placed he thinks beyond all possibility of doubt; whilst in others, the motion being less rapid, observations at a future and more distant period are required to establish the fact with security.

As amongst the most interesting of the double stars, we may enumerate the following: — ε Bootis, γ Virginis, α Geminorum, (or Castor), σ Coronæ Borealis, η Cassiopeiæ, 61 Cygni, ξ Ursæ Majoris, and 70 Ophiuchi.

ε Bootis.

Large white, small blue; distance, 3 seconds and 4-tenths; period, about 822 years—motion direct *.

γ Virginis.

8th and 8½ magnitudes; both white; distance, 3 seconds and 3-tenths; period, about 540 years—motion retrograde †.

* nf sp. † np sf.

α Geminorum (or Castor).

3rd and 4th magnitudes; both white; distance, 4 seconds and 8-tenths; period, about 373 years—motion retrograde.

σ Coronæ Borealis.

6th and 8th magnitudes; distance, 1 second and 5-tenths; period, about 169 years—motion direct.

η Cassiopeiæ.

6th and 9th magnitudes; large red, small green; distance, 9 seconds and 9-tenths; period, about 700 years—motion direct.

61 Cygni.

7th and 8th magnitudes; both white; distance, 15 seconds and 4-tenths; period, about 493 years—motion direct.

ξ Ursæ Majoris.

6¼ and 7th magnitudes; both white; distance, 2 seconds and 4-tenths; period, about 71 years—motion retrograde.

70 Ophiuchi.

8th and 8¼ magnitudes; distance 4 seconds and 8-tenths; period, about 53 years—motion direct.

TRIPLE STARS.

12 Lyncis.

A of the 7th, B of the $7\frac{1}{2}$, and C of the 9th magnitudes; of AB, distance, 2 seconds and 5-tenths; of AC, 9 seconds and 2-tenths; period of AB (or the close pair) 646 years —motion retrograde; whilst AC (or the distant pair) have not materially changed.

ξ Scorpii.

A of the 7th, B of the 7th, and C of the 9th magnitudes; of AB, distance, 1 second and 4-tenths; of AC, 7 seconds.

The close pair, AB, has suffered no alteration since it was observed by Sir William Herschel, in 1782.

Whereas the period of the distant pair, or AC is probably about 1406 years—motion retrograde.

Two instances are furnished in which occultations of stars by others have occurred, they are δ Cygni, and ζ Herculis; and this fact is confirmed by the inquiries of Professor Struve, at Dorpat; and some additional confirmations of the proper motions of other stars have been recently made by Dr. Brinkley, now Bishop of Cloyne, at Dublin.

When the importance of an acquaintance with the position of the fixed stars in the heavens is considered, on the

accurate knowledge of which all our data in refined astronomy, and many of those in practical navigation, depend; and when the new and sublime views of the arrangements of infinite wisdom in the starry heavens, resulting from these inquiries are considered, you will, I am sure, approve of this vote of your Council.

Mr. Herschel has, on another occasion, enjoyed the honour of the Copley medal: and a like mark of your respect is surely due to his fellow-labourer, who having provided his own instruments, at a great expense, has employed them at home, and carried them abroad, trusting entirely to his own resources, and pursuing his favourite science in the most disinterested and liberal manner, communicating all his results to this Society.

There is a reason likewise which must be almost considered as personal. Who ever has seen the methods in which observations of this kind are conducted, must be aware of the extreme fatigue connected with them, of the watchful and sleepless nights that must be devoted to them, of the delicacy of manipulation they require, and of the sacrifices of ease and comfort they demand!

In dwelling upon this award, there is another circumstance to which I cannot but allude; it fixes, as it were, the perfection and delicacy of the instruments employed, without which all labour would be in vain. In these instances of research, man, as it were, conquers space, and

triumphs over time; and by almost infinitely minute and delicate resources, by aids which may be called microscopic, contemplates and embraces the grandest objects: and if the pure, mathematical sciences obtain their great truths by the strength of the human intellect, facts of this kind on which they must reason, are owing to the wonderful perfection of the human eye and hand, applied to produce combinations, which measure portions of space, formerly believed immeasurable by human powers.

Mr. South,

I have great pleasure in presenting to you this medal. Receive it as the ancient olive crown (to use a metaphor taken from the Olympic conquerors) of this Society; and it has a higher claim to this appellation, as belonging to arts of peace, which can only benefit mankind.

Researches of the kind, for which you receive this reward, if they have not the immediate effect or striking popularity of some other labours, yet are secure in their value, and sure of endurance. Other pursuits and successes may be connected with the passions, prejudices, and uneasy feelings of the day. These will outlive them; they require time for their complete developement; they appeal to time for the meed of glory belonging to their discoverers.

Mr. South, your name is committed, as it were, to posterity, for more than ten centuries in the largest period of

revolution assigned to a double star: and it must be some satisfaction to you to know, that at so immense a distance of time, should our records remain, like those of Hipparchus and Ptolemy, when the brazen instruments with which you have observed are decayed, and the structure under which we stand crumbled into dust, your name is sure of being recalled with that of the two Herschels, by some accurate observer of the heavens.

I trust that this motive, as well as the nobler one of utility, will induce you to pursue and persevere in those researches, and steadily to apply your mind, your undivided attention, to this one great object, secure that you will reap abundant fruits from your labours, and that you will enjoy the pure pleasure resulting from the conviction, that you have increased the stores of human knowledge, and laboured not merely for those who are now living, but likewise for future generations.

THE END.

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